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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOL-
OGY AND PLANT QUARANTINE, AGRICULTURAL RE-
SEARCH ADMINISTRATION, 1945 Washington 25, D. C.

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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE, AGRICULTURAL RESEARCH ADMINISTRATION, 1945

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., September 15, 1945.

MR. P. V. CARDON,
Agricultural Research Administrator.

DEAR MR. CARDON: I submit herewith a report of the work of the Bureau of Entomology and Plant Quarantine for the fiscal year ended June 30, 1945.

Sincerely yours,

P. N. ANNAND, *Chief.*

INTRODUCTION

NEW developments resulting from research in the field of entomology promise far-reaching effects upon the general control of insect pests in the future. They will also affect large-scale programs to combat outbreaks of injurious insects and should, though perhaps in a less direct way, influence quarantine activities. Of especial interest is the extension of the usefulness of the aerosol method of dispersing insecticides, both the liquefied-gas aerosols and those in the form of smokes.

Utilization of various types of distributors has made possible the practical use of airplanes for the application of sprays. A concentrated spray, broken into very fine droplets, can be effectively applied from the air. As little as 1 gallon will give good coverage over an area as large as an acre on certain types of foliage. This opens up new possibilities for the application of liquid insecticide materials from the air.

Similar improvements have been made in equipment for applications from the ground. Extensive research on new insecticides has shown the important new material DDT to hold much promise against agricultural insects. Methods and formulations for its use for the control of disease-carrying insects have been developed, recommended to the military forces, and used effectively by them on a large scale. Though not effective against all insects, experimentation thus far indicates that it will be useful against many important ones which are injurious to livestock and crops. Research on these and other new and improved methods for pest control is continuing. The more promising methods are being rapidly adapted to aid in efforts to control pests of major importance and to maintain the production of food, lumber, and fiber. As promptly as possible information concerning these new developments is made available so that the public can also make use of them for combating pests on the farm and in the home.

Much of the research concerned with the development of materials and equipment for the control of disease-carrying insects has been done under a transfer of funds from the Office of Scientific Research and Development.

Several changes in the administrative set-up of the Bureau have occurred during the year. James A. Hyslop, head of the Division of Insect Pest Survey and Information since its establishment in 1934, retired on July 31, 1944. He had been in charge of the Insect Pest Survey since its organization in 1920. G. J. Haeussler was placed in charge of the Insect Pest Survey and Information work. On March 31, 1945, Rolla P. Currie retired after having served as Bureau editor since 1904. Effective April 1, the personnel and activities of the Editorial Office were transferred to and made a section of the Division of Insect Pest Survey and Information. Delos L. Van Dine, head of the Division of Fruit Insect Investigations since 1933, retired June 30, 1945. Bennet A. Porter, assistant leader of the fruit-insect work for the past 17 years, was made head of the Division.

RESEARCH INVESTIGATIONS

INSECT-CONTROL DEVICES AND METHODS IMPROVED

DEVELOPMENT AND USE OF INSECTICIDAL AEROSOLS

Investigations on insecticidal aerosols for the control of insects affecting the armed forces have been continued under a transfer of funds from the Office of Scientific Research and Development. Aerosol solutions, containers, and valves of various types were tested for the Army and Navy. The relation of particle-size distribution of aerosols to insecticidal efficiency was studied. A series of tests for the evaluation of proposed aerosol formulas was developed, including corrosive effect on containers, stability of solution, particle-size distribution, clogging of nozzles, odor, staining, and other properties.

In cooperation with the University of Maryland, the Bureau tested aerosol formulas that gave good control of several vegetable insects in the field and in the greenhouse. When the DDT-containing aerosol was applied in the field under a shallow, portable hood, satisfactory kills were obtained of aphids, thrips, leafhoppers, the Colorado potato beetle, flea beetles, webworms, lacebugs, and cabbage caterpillars on potato, pea, bean, onion, spinach, squash, melon, eggplant, tomato, kale, and lettuce. The hood served to concentrate the aerosol as it was released from a high-pressure container which formed part of the distributing device.

Early in 1945 the DDT aerosol with methyl chloride as the propellant agent was used on large field plots of peas for pea aphid control, and encouraging results were obtained. In the greenhouse DDT in aerosol form was found to be very effective against several species of insects and related forms affecting vegetables grown under glass, including thrips, aphids, white flies, gnats, crickets, cockroaches, and sowbugs. Under greenhouse conditions the aerosols were applied with special dispensers.

Further tests were made in the adaptation of heat-generated, or "smoke," aerosols for the control of agricultural pests. The aerosol from a generator developed for the military services gave promising results when applied from airplanes against larvae of the gypsy moth.

infesting forest areas in New England. New types of generators, designed specifically for use in insect control by the military forces, have made possible rapid progress in the agricultural field.

AERIAL APPLICATION OF INSECTICIDES

Considerable attention has been devoted to testing and observing the effect of applications of insecticides by airplane, in cooperation with State and other governmental agencies, commercial aircraft dusting companies, and growers.

In North Carolina it was found that rotenone dust applied by airplane against the Mexican bean beetle was not so effective as when applied by ground machine. The airplane applications reduced the number of beetles by approximately 80 percent, but had little effect on the larval population, owing apparently to the lack of insecticide coverage on the under side of the bean leaves, where the beetle larvae feed. Observations in Washington, where cryolite dust was applied to potato fields by airplane to combat potato flea beetles, showed that the insecticide was distributed principally on the tops of the plants, and not at a uniform rate. Moreover, the flea beetle populations were not reduced to a degree equivalent to that obtained when the same insecticide was applied with ground equipment.

In Washington and Oregon good results were achieved from aerial applications of dust mixtures containing DDT or rotenone for the control of the pea weevil and the pea aphid. In these tests the airplanes were as effective as ground equipment under comparable conditions when the same insecticide was used. In Arizona satisfactory results were recorded in using airplanes to apply dusts containing DDT for the control of *Lygus* plant bugs and the beet leafhopper on sugar beets grown for seed. Hornworms and flea beetles on tobacco were controlled successfully in North Carolina by airplane applications of cryolite dust mixtures. The results obtained thus far indicate that the use of aircraft for applying insecticides to some vegetable and tobacco crops has a promising future.

Preliminary tests in which both DDT and rotenone were used indicated that effective insecticidal control of the European corn borer can be obtained with aerial equipment.

Owing to the success obtained in small-scale experiments in 1944 in controlling forest defoliators with concentrated DDT sprays distributed in finely atomized form from an airplane, the 1945 program in this field has been greatly expanded. Improved spray formulas have been tested during the current season against various forest-insect pests.

Considerable progress in improving and simplifying distributing apparatus has been made through cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. An extensive series of forest and plantation plots in the United States and Canada have been treated with various dosages and formulas for the control of the gypsy moth, the spruce budworm, the pine tip moth, the pine spittle bug, and the hemlock looper.

Special emphasis has been given to airplane applications of DDT in Quebec, Ontario, New York, and Colorado to determine whether the spruce budworm can be economically controlled by this method. Preliminary results of these tests are very encouraging.

A Navy helicopter, together with a pilot and technical personnel, has been made available to this Bureau by the United States Coast Guard during the 1945 season for experiments in New Jersey, New York, and Connecticut. The helicopter is equipped with a distributor for releasing DDT solutions as fine sprays. Thus far these tests have demonstrated that the helicopter may prove very useful in treating woodland areas too large for economical treatment by ground equipment and too small for economical fixed-wing plane applications.

MIST-BLOWER APPLICATIONS OF INSECTICIDES

Through the cooperation of the Connecticut Agricultural Experiment Station, arrangements have been made with commercial companies for testing the latest models of power blowers in dispersing insecticides in finely atomized form. Different types of nozzle assemblies have been developed for atomizing the sprays, and introducing them into the air blast.

It has been found that by this method the tallest shade trees can be effectively covered and the spray can be blown laterally for distances up to 300 feet. Much less spray material is used by this method than by the conventional application of dilute sprays with power sprayers. For example, 275 shade and orchard trees have been treated effectively for the control of a number of defoliators with 12 gallons of concentrated DDT spray, whereas several hundred gallons of dilute spray applied with a power sprayer would have been required to have treated that number of trees. The mist blower is especially well adapted for treatment of shade and roadside trees and orchards. It may also prove useful in treating truck crops and gardens. When used in conjunction with apparatus for generating aerosols by heat, these blowers increased materially the depth of effective penetration of the DDT-bearing smokes into forested areas.

FUMIGATION METHODS AND SCHEDULES

In small-plot fumigation tests at Whittier, Calif., against the California red scale on citrus, approximately the same kills were obtained under plastic-treated gastight tents with one-third to two-thirds the amount of hydrocyanic acid gas required as when canvas tents were used. Under canvas tents somewhat better kills of this insect were obtained when the hydrocyanic acid was introduced with the blower applicator developed by this Bureau for this purpose than with the vaporizer now in common use. With a new dosage schedule and this blower applicator it was found possible to obtain the same concentrations from night to night.

Improved emulsible mixtures were developed for the fumigation of Japanese beetle larvae in soil.

Studies on methyl bromide fumigation for the elimination of the oriental fruit moth in harvested fruits were made in cooperation with the California Department of Agriculture. Schedules were developed for the treatment of larvae in fruit at five temperature levels between 40° and 80° F., and of eggs that might be associated with fruit at five levels between 50° and 70°. The effect of cold storage alone on the larvae was determined. Tests with overwintering larvae, in an attempt to lower the dosages now required for precautionary treat-

ment of nursery stock, indicated that such a reduction cannot be made with safety. Larvae from eastern and western sources (New Jersey and California) were compared and found to react similarly. The tolerance of fruits to methyl bromide fumigation was also studied. No injury followed the fumigation of summer-maturing fruits. Fall apples showed no injury when fumigated before being placed in cold storage or after 6 weeks of storage, but treatment during the first 6 weeks of storage resulted in injury of the varieties tested.

In tests conducted in cooperation with the Delaware Agricultural Experiment Station, varietal differences were indicated in tolerance to methyl bromide fumigation schedules approved under the Japanese beetle quarantine. Out of 19 varieties tested, 5 showed slight to moderate injury at the regulation dosage. The remaining 14 varieties, however, were still unaffected when the dosage was increased 50 percent. Further development of schedules for treating products suspected of carrying gypsy moth egg clusters permitted the fumigation of 105 freight-car loads of Christmas trees and greens, at an estimated saving of 262 man-days of labor by inspectors and \$22 to \$31 per car in hauling costs.

The factors governing tolerance of camellia plants to the fumigation schedules recommended for the elimination of white-fringed beetle larvae were studied, and several changes in handling practices were recommended to reduce plant injury. Provisional fumigation schedules for hay and peanuts, possible carriers of white-fringed beetle eggs, were developed and recommended. Investigations were continued on soil fumigants, atmospheric fumigation schedules for nursery plants, and dips for small seedlings.

Progress was made, by means of chemical analysis, in studying the factors that influence the concentrations of hydrocyanic acid gas present in the routine fumigation of freight cars entering this country from Mexico. The mortality of pink bollworm larvae in cottonseed when exposed to these concentrations was determined. Determinations of gas concentrations were made in all six fumigation plants along the Mexican border, preliminary to an effort to bring them to a uniform level of tightness and performance.

CROP-MANAGEMENT PRACTICES

Public and private owners of white-pine timber in Idaho and Montana are much interested in the possibilities of using forest-management practices as a means of reducing losses caused by the mountain pine beetle. This beetle has been a more or less constant, but very serious, drain on the remaining supply of mature white pine, especially in those areas where the associated tree species, such as fir and hemlock, are competing with the white pine for space, nutrients, and soil moisture. Many areas are too heavily stocked, with the result that the white pine is weakened and subject to beetle attack.

Plans are being made to encourage partial cutting of such stands, removing various proportions of the total volume and of the different tree species. Considerable study will be required to determine just what cutting practice is best suited to each condition. A greatly improved market for the formerly low-value fir and hemlock has made it possible to apply more intensive management to these stands; consequently entomologists and foresters are looking forward to increased

production of timber and a marked reduction in insect losses in this white-pine region.

The spruce budworm is continuing its devastation of the spruce-fir forests of Ontario and Quebec. This Bureau and the Forest Service are conducting intensive investigations, in cooperation with the Dominion and Provincial Governments in Canada, on the biology, habits, and ecology of the insect in the Province of Quebec, with the objective of improving methods of control through forest management. A logging-cost study has been initiated within the timber limits of the Canadian International Paper Co. in Quebec. A 500-acre area of woodland has been divided into blocks where different cutting methods will be carried out. The area is being cruised and marked for cutting, and cost records will be kept when the area is cut. These figures will be available for use in improving cutting practices in the United States. This work should give much information on the practicability of the Bureau's suggestions for budworm control by forest management.

Plans have also been made for cruising and marking large areas in Maine for cutting operations to minimize losses from the spruce budworm should an outbreak occur in that area. Work along these lines is being considered for the States of New Hampshire, Vermont, and New York.

The most practical method of disposing of sugarcane borers overwintering in summer-planted cane is to shave off the shoots just below the soil surface, cover them with 2 or 3 inches of soil in furrows between the rows, and leave them undisturbed until after the first generation emerges or until cultivation is necessary.

Chemical defoliation of cotton plants increases the quantities and improves the grades of lint picked by hand, strippers, sleds, and mechanical harvesters. It was practiced on large acreages in 1944 to help overcome the shortages of farm labor. Many growers consider defoliation the key to successful mechanical harvesting. Since the squares and small bolls are also shed with the leaves and the green bolls are caused to open promptly, defoliation destroys the food of insects and may prove to be as important as early stalk destruction in insect control. Calcium fluosilicate applied in liberal quantities by airplane or ground dusting machinery was found to defoliate as well as calcium cyanamide under the climatic conditions of last season, but the amounts required per acre and the effects of moisture on its efficiency remain to be determined.

ENCOURAGING RESULTS OBTAINED WITH NEW AND IMPROVED INSECTICIDES

DDT WIDELY TESTED

Many of the outstanding preliminary results obtained with DDT against a number of injurious insects were mentioned in last year's report. These and the availability of somewhat larger quantities of the material for experimentation led to the undertaking of more extensive studies to determine its insecticidal uses. Except for the limited quantities available for experimental use during the year, the armed forces required the entire output. However, there is already a great popular demand for DDT insecticides and for information concerning their use and value against all kinds of insect pests.

The results of the experimental work are being made available as rapidly as conditions permit. During the year 92 articles dealing

entirely with work on DDT were approved for publication. The Bureau issued 27 processed publications containing information on that subject, one of which contained 22 parts summarizing the results of experiments conducted by State agricultural experiment stations, agricultural colleges, and other non-Federal research organizations. In addition, a number of articles on DDT by Bureau workers appeared in outside publications.

The information already at hand and the reports on further experiments now under way will be of great value in determining safe, effective, and practical uses of DDT insecticides. Much still remains to be learned, however, concerning the best formulations and dosages for use against specific pests and on given crops. Certain of its limitations must be worked out before DDT can be used with safety for some purposes. Used under certain conditions, it is known to be injurious to beneficial insects, to fish, and to insectivorous birds. More information is needed as to its possible accumulative effect in soils. In the short time this new insecticidal material has been available for experimentation it has not been possible to obtain satisfactory answers to all these questions.

Pests affecting man.—The effectiveness of DDT in the control of human lice has been well demonstrated, and this new material has been found to be outstanding in its toxicity to mosquitoes. An important accomplishment in this field is proof of its residual value in controlling malaria. For the first time a material has been shown to be effective in reducing mosquitoes and flies by simply spraying it on the walls of dwellings or barns. Research on DDT has also given mosquito-control workers for the first time a material that can be applied from various kinds of aircraft and with one operation will destroy the larvæ in the water and the adult mosquitoes on the wing.

Liquid larvicides containing DDT were found to be more effective in the destruction of mosquito larvae than were dusts containing the same toxic agent. In some instances 5 percent of DDT in fuel oil applied at the rate of 0.02 pound of DDT per acre was successful in destroying mosquito larvae. Entomologists found that when applied at this rate the DDT-oil was injurious to snails and such other aquatic life as fairy shrimp, tadpoles, and several species of aquatic insects.

Woodland plots in Georgia treated at the rate of 1 pound of DDT per acre were freed from infestations of the lone star tick and the black-legged tick throughout the greater part of their season of activity. The best results were obtained when emulsions containing 1 pound of DDT to 50 gallons of water were sprayed on the ground, weeds, and low-growing bushes over an area of 1 acre. Fairly good control was also established with a 10-percent DDT dust applied at the rate of 1 pound per acre. Applications of similar amounts of DDT were not satisfactory for control of the American dog tick, although many of the results were promising. The common chigger was not controlled by applications of as much as 6 pounds of DDT per acre.

Residences infested with the brown dog tick were satisfactorily treated with 5-percent DDT-oil spray, and with 10 percent of DDT in pyrophyllite.

A dust containing 10 percent of DDT in pyrophyllite was successfully used at Savannah, Ga., and in eastern Texas to control infestations of rat fleas in buildings. The dust was applied to rat burrows

and their runs as well as to the floors of buildings infested by rats and their fleas. Infestations of the oriental rat flea, the European rat flea, and other species were greatly reduced within a few days after such treatments. This method promises to be important in the control of endemic typhus, plague, and other flea-borne diseases.

DDT was tested for control of the stablefly (dog fly) in marine-grass deposits along the coast of western Florida. It was found that 0.5 percent of DDT in bay-water emulsion applied at the rate of about 2 gallons per 100 square feet of grass surface gave effective control of the emerging flies. The young flies were killed by walking over the treated surfaces in the interval between emergence and flight. It was found that residual oil obtained in the manufacture of DDT may be used in an oil emulsion to control dog flies if applied at five times the concentration effective when a technical grade of DDT is used.

Livestock pests.—Practical methods for controlling the horn fly, a contributing agent of screwworm infestations, were more clearly defined during the year by a continuance of experiments with DDT in solutions, emulsions, suspensions, and dusts. Control was obtained for 7 days by using approximately 1 fluid ounce per animal of a spray containing 4 percent of DDT in deodorized kerosene.

The use of DDT in oil on animals is considered hazardous, however, because some of the toxicant may be absorbed by the animal, and such combinations cannot now be recommended.

Emulsions and suspensions of DDT in water applied at the rate of 2 grams of DDT per animal gave excellent control of horn flies for 2 to 3 weeks. Comparable control for the same length of time was obtained with emulsions containing 0.2 percent of DDT, used as spray or dip. Concentrations of 0.1 to 0.15 percent DDT in emulsions were less satisfactory.

Horses infested with the winter tick were treated experimentally with emulsions containing 0.4 and 0.8 percent of DDT. The latter gave protection for a longer time. It was prepared by dissolving 20 percent (by weight) of DDT in soluble pine oil and diluting this solution with water at the rate of 6 ounces per gallon. The emulsion was applied with a sponge to saturate the hair of the animals. Two thorough applications of the emulsion during the tick season prevented attachments of this species and killed ticks that had attached prior to treatment. This small amount of pine oil used in the emulsion has shown no injury to the treated animals.

Tests were made to determine the minimum concentration of DDT required for the control of lice on cattle. When cattle were treated by immersion in a dipping vat, all the motile forms of the short-nosed louse and the red louse were killed by a concentration of DDT as low as 0.08 percent. For killing all the motile forms of the long-nosed louse and the capillate louse 0.15 percent of DDT was required. Although there was no evidence that any louse eggs were killed, the residue left in the hair killed the young lice that hatched during the 4 or 5 days following the dipping. A second dipping 16 days after the first eliminated the infestation.

Field tests showed that one dipping of goats in a solution containing DDT and soluble pine oil killed the motile stages of all three common species of goat lice. This dip was prepared by diluting in 100 gallons of water 10 pints of a stock solution made of 1 part of DDT in 5 parts of soluble pine oil.

Household insects.—In New England and Texas large storages of raw wool infested with clothes moths and carpet beetles were treated with sprays containing 1 percent of DDT. From these preliminary tests it appears that DDT will play an important part in the control of stored stocks of raw wool and mohair.

In cooperation with the National Pest Control Association and other agencies, the Bureau conducted control experiments with DDT on a wide variety of insects that affect household and stored products. With a minimum of expense it was thus possible to acquire a large amount of information on DDT in several sections of the United States. Many infested kitchens, cheese-processing plants, meat establishments, warehouses, hospitals, and dormitories were treated with DDT dusts and sprays for the control of cockroaches, flies, bedbugs, scorpions, silverfish, and mites. The preliminary results by the several workers have been consistently good against all these pests except cockroaches, cheese mites, and tropical rat mites, which were not satisfactorily controlled by DDT.

Fruit insects.—The little fire ant has at times caused such marked discomfort to workers in Florida citrus groves that they have refused to continue their work. No effective control was available until recent studies indicated that DDT applied to the trunks and main branches of the trees will destroy this ant and prevent reinfestation. DDT was most effective when dissolved in No. 2 fuel oil, which was then emulsified and diluted to give $\frac{1}{4}$, $\frac{1}{2}$, or 1 pound of DDT per 100 gallons of water.

In 1944 DDT gave outstanding control of the codling moth in tests in New York, Maryland, West Virginia, Indiana, and Washington. From $\frac{1}{2}$ to 1 pound of powdered technical DDT appeared superior to 3 pounds of lead arsenate or cryolite for codling moth control; however, where such quantities of DDT are used mite populations are likely to increase to a high level and in the Pacific Northwest the woolly apple aphid may again become a problem. Yellowing and dropping of foliage occurred on some apple trees treated with DDT, but heavy mite populations appeared to be largely responsible. At Vincennes, Ind., combination sprays containing only 4 ounces of DDT to 100 gallons of lead arsenate or nicotine bentonite solution in half the usual concentration reduced the number of wormy apples to less than half of that resulting from use of the usual concentration of these materials alone. Moreover, mite populations did not increase appreciably where such combination sprays were used.

At Beltsville, Md., atomized concentrated solutions of DDT gave remarkable results in preliminary laboratory tests. A concentrated solution of DDT in fuel oil applied by airplane at the rate of 5 pounds of DDT per acre in June 1945 was ineffective and caused injury to fruit and foliage. Although residues of DDT on harvested fruit have been found difficult to remove, they do not appear to present a serious problem, because the dosages necessary to give effective control will probably not leave residues on harvested fruit heavy enough to be considered dangerous to human health.

Injury to peaches by the oriental fruit moth was reduced considerably in field plots sprayed with DDT, 1 pound per 100 gallons, in an experiment conducted in cooperation with the New Jersey Agricultural Experiment Station. Two applications, one each just before the appearance of both second- and third-brood larvae, were more effective

than one application made just before the appearance of the second brood. The DDT sprays reduced the abundance of parasites but did not eliminate them entirely.

One to three applications of DDT (micronized with an equal quantity of pyrophyllite and with glue as a wetting agent) at the rate of 1 pound to 100 gallons of spray gave almost complete control of Japanese beetles on peach, early apple, grape, blueberry, and a miscellaneous group of ornamental and shade trees and shrubs. Applications after the first spray were necessary only to protect new growth. In soil tests 25 pounds of DDT per acre appeared to be more effective against third-instar larvae in various types of soils than 1,000 pounds of lead arsenate. At this dosage the material was found to be as effective after 75 weeks in the soil as when first applied. Technical DDT appeared to be as toxic as the purified form to third-instar larvae in the soil; however, early in 1945 technical DDT affected adversely the growth of green beans, lima beans, and soybeans and the productivity of green beans and soybeans, as it did in 1944, whereas as much as 100 pounds of purified DDT per acre did not.

Preliminary field experiments in Mexico with DDT in petroleum spray oils for control of the citrus blackfly gave no significant reduction over that obtained from the oils alone. Field experiments with DDT dusts and sprays on mango trees showed no significant reduction in populations of the Mexican fruitfly. Smokes from smoldering mango leaves, however, gave a marked reduction in fruitfly populations.

In Hawaii DDT dusts on tomatoes gave nearly 70-percent control of the melon fly as based on the mature crop.

Cereal and forage pests.—DDT was tested against the more important insect pests of cereal and forage crops. Good control of the European corn borer was provided by various spray and dust formulations applied with ground or aerial equipment.

Dust mixtures of DDT were found very effective as barriers against chinch bugs, but when applied directly on the bugs infesting sweet corn, popcorn, and oats, good control required heavy dosages.

Injections of DDT in mineral oil into the silk channels of the ears gave almost perfect control of the corn earworm in both green and maturing stages of sweet corn and hybrid seed corn. It was the only insecticide that protected seed corn until harvest. Promising results were also obtained with certain water emulsions of DDT atomized on the ears. The hazard of toxic residues of DDT in sweet corn ears has not yet been definitely determined, however.

Heavy applications of DDT dusts and sprays were found necessary for effective control of grasshoppers in dense stands of alfalfa.

DDT dust was more effective against the vetch bruchid than rotenone dust or a liquid bait spray composed of calcium arsenate, sugar, and water, and gave excellent control of heavy infestations in Oregon. It also gave outstanding control of *Lygus* bugs in seed alfalfa in Utah.

Insecticides containing DDT gave good control of the potato leafhopper on peanuts and alfalfa, the tobacco thrips on peanuts, and a webworm on lespedeza.

DDT dusts and sprays were effective as both stomach and contact poisons against white-fringed beetle adults. Kerosene containing 2 and 4 percent of DDT was effective as an ovicide in tests against that insect.

A 6-percent solution of DDT in refined kerosene sprayed on the walls and woodwork of a mill, a warehouse, and farm-type wooden grain bins killed large numbers of the grain-infesting insects that were burrowing or hiding in them.

Wrappings coated or impregnated with DDT were highly effective in preventing insect entrance into packages of cereals.

DDT mixed with seed stocks at a concentration of 0.05 percent by weight gave complete protection from infestation regardless of the moisture content of the seed. Experiments also indicated that much lower percentages of DDT are effective for that purpose when it is finely ground with an inert carrier such as pyrophyllite.

Truck crop and garden insects.—DDT gave outstanding protection from caterpillar damage on cabbage in South Carolina during the spring of 1945. Dust mixtures containing 1 or 2.5 percent of DDT were superior to all other insecticides tested, including those recommended formerly for cabbage caterpillar control, such as rotenone, pyrethrum, cryolite, calcium arsenate, and paris green. A single application of 2.5-percent DDT dust to the spring crop just before the heads began to form provided protection for 3 weeks to 1 month from damage by the imported cabbageworm, the cabbage looper, the diamondback moth, the cabbage webworm, and cutworms, all of which feed on the leaves. No additional applications were necessary, even though early and heavy infestations of green cabbage caterpillars occurred on comparable plantings of cabbage not treated with insecticides.

If current research reveals that the use of DDT on cabbage does not incur a harmful residue hazard or result in plant injury under the widely divergent conditions where this crop is grown in this country, it appears that DDT will prove to be a very effective remedy for cabbage caterpillars. Until more definite knowledge on the residue situation is obtained, the use of DDT on cabbage and related crops will be subject to the same limitation as that of arsenic and fluorine compounds.

Lygus bugs reduce materially the production of viable sugar beet seed, and stinkbugs, when numerous, prevent the seed from forming. During the past year large-scale tests in commercial fields demonstrated that one application, by airplane or with conventional ground equipment, of a dust containing 5 percent of DDT at the rate of 30 to 40 pounds per acre has exerted a control of *Lygus* bugs surpassing that of two applications of the pyrethrum-sulfur or sulfur-dust mixture. However, these DDT treatments were not so effective against associated species of stinkbugs. Studies late in the 1944 season indicated that the use of DDT did not affect adversely the yield of sugar beet seed or its viability. The effect of this material on the build-up of aphid or red spider populations on the sugar-beet seed plants remains to be determined.

In tests against the onion thrips on onions grown for seed both dusts and sprays containing DDT were very effective in reducing thrips populations, and were superior to sweetened sprays containing tartar emetic or nicotine sulfate, used heretofore against this thrips. It is not yet known whether this reduction in thrips populations will be reflected in increased yields of the onion crop grown for culinary purposes, at a reasonable cost.

DDT in dust and spray forms and as an aerosol has proved to be very toxic to a number of common insect pests affecting vegetables. On the other hand, it has shown low toxicity against some others, notably the Mexican bean beetle, the tobacco hornworm, the turnip aphid, the melon aphid, the cabbage seedpod weevil, the common red spider, and the tomato russet mite. The tolerance of vegetable plants to this insecticide has been high. Tests conducted to date show that beans, peas, potatoes, tomatoes, cabbage, turnips, onions, beets, lettuce, sweetpotatoes, and eggplant are tolerant to low strengths of DDT in dust and aerosol form, but that some injury to squash and other cucurbits may be expected even when this material is applied at strengths and dosages which do not affect other types of vegetables. The tolerance to sprays containing DDT is still under investigation.

Experimental work which has been done with DDT against many of the common insects that attack vegetables gives an insight into its future usefulness and limitations to the vegetable grower. The statements given in the following paragraphs are based upon the effect of various DDT formulations on the insect and its host plant, but they do not take into account the possibility of harmful residues on vegetables with edible foliage or the effect repeated applications may have on beneficial insects or on the productivity of the soil.

1. If the insecticide containing DDT can be successfully mixed and used with fungicides, it will serve as an excellent remedy for several widespread pests of potatoes, such as the Colorado potato beetle, the potato leafhopper, the potato flea beetle, the potato psyllid, and possibly aphids affecting potatoes.

2. If the residue hazard is found to be negligible, it should serve as a remedy for caterpillars on cabbage in areas where the cabbage aphid or turnip aphid is not a problem.

3. On tomatoes in California DDT will probably prove to be the most effective remedy yet found for the tomato fruitworm.

4. On peas it can be used as a satisfactory treatment for the pea weevil and probably for the pea aphid.

5. On squash, pumpkins, melons, and other cucurbits its use will be limited because of its adverse effect upon these plants; it is ineffective against the melon aphid.

6. On sugar beets grown for seed, unless some unforeseen difficulty arises, present indications are that a 5-percent DDT dust will be a standard remedy for *Lygus* and other types of plant bugs which attack seed beets. It may also be useful against the beet leafhopper under certain conditions.

7. For the market gardener who grows different types of vegetables and who has the Mexican bean beetle to contend with, DDT will not be a satisfactory all-purpose insecticide; a combination of rotenone and pyrethrum will probably be more effective.

In aerosol form DDT will probably find its greatest usefulness in the control of plant lice, such as the pea aphid and aphids that attack potatoes. Preliminary work has shown the DDT aerosols to be effective initially against other insects, but their residual value has not been determined. DDT in aerosol form should also provide a convenient and effective method of controlling many of the pests that are found in the greenhouse.

Even with this encouraging outlook for this new insecticide, the most satisfactory formulations, dosages, and methods of application

remain to be determined. Additional information on plant tolerance, accumulations in the soil, and residues on the plant is needed. The relation of temperature, humidity, and other climatic factors to the reaction of the chemical to the insect also needs further study.

Forest and shade-tree insects.—Because the general use of DDT over large forested areas cannot be recommended until the possible detrimental effects on beneficial insects, fish, and wildlife have been determined, large wooded areas were treated in 1945 for a study of this problem. Extensive samplings of these areas before and after treatment to determine the effect of DDT on the total fauna of the forest were made in cooperation with the Fish and Wildlife Service of the United States Department of Interior. The results of these investigations have not yet been summarized. Provided there is no serious hazard to such life, preparations containing DDT will be far more practical against many forest insects than the insecticides now in common use.

Experiments on control of the gypsy moth with DDT applied by aircraft were conducted in Pennsylvania, New York, and New England, in cooperation with the Fish and Wildlife Service, the Audubon Society of America, and various State agencies, including the Pennsylvania Departments of Agriculture and Public Health and the New York State Department of Conservation. The most extensive project was in Pennsylvania, where 3,864 acres were treated on the property of a public service company. In New York State 785 acres and in New England 331 acres were sprayed with DDT. Various formulations and dosages were tested with different types of equipment. In 1944, it was found that 5 pounds of DDT in 5 gallons of spray per acre gave complete control of the gypsy moth, but the tests in 1945 have shown that much smaller dosages are effective. In these later tests the moth was controlled with $\frac{1}{4}$ pound of DDT in 1 gallon of solvent per acre. This season's work has demonstrated conclusively that DDT is the most effective and economical insecticide discovered for control of the gypsy moth, and its distribution by aircraft and improved spray equipment offers for the first time a practical means for controlling woodland infestations of this insect.

The Bureau also experimented with airplane applications of DDT for control of the spruce budworm and the LeConte sawfly in New York State and Massachusetts. Most of the spruce budworm work was done in Canada in cooperation with the Dominion Government and the Provinces of Ontario and Quebec.

It has been found that DDT is very effective against the group of elm insects suspected of transmitting the elm virus disease organism.

Cotton insects.—Numerous tests in the past to control the pink bollworm with arsenical, fluorine, and organic insecticides failed to develop an effective control measure. Many of the insecticides tested killed a small percentage of the young larvae as they crawled over the plant before entering the squares or bolls, but none caused sufficient reduction in damage to be of practical value for use by growers.

Preliminary experiments late in the season of 1944 indicated that DDT was the most promising material that had been used against the pink bollworm. Dust applications of approximately 15 pounds per acre of DDT in pyrophyllite, beginning when the bolls were large enough for the pink bollworm to infest them and repeated at 5-day intervals, caused from 53 to 94 percent reduction in larval popula-

tions, depending upon the strength of the material and the number of applications. The best previous results had been about 50-percent reductions with cryolite. Late bolls in the DDT-dusted plots were not sufficiently damaged to reduce the grade and yield, whereas the untreated cotton was severely damaged. In tests where pink bollworm moths were encaged on plants heavily dusted with DDT, no larvae developed in the bolls. Since small larvae exposed to a film of the dust were not all killed, the reduction may have been due to killing the moths before they oviposited. If this is confirmed by future tests, it will be of great importance, for the larvae can be reached by insecticides for only a short period before they enter the bolls or squares.

In view of the encouraging results and the finding of pink bollworm infestations in a number of additional southern Texas counties, extensive laboratory and field experiments with DDT were begun in 1945. Various formulations of DDT—in dust form with several diluents or as sprays in water suspension, emulsions, and solution in oils and other solvents—are being used to find an effective and economical method of application that will not injure the cotton plant. The development of new spraying equipment by the Bureau, which will cover an acre of cotton with 2 to 3 gallons of finely atomized, concentrated spray, has opened up a new method of application, as spraying by airplane has not heretofore been practical. Large acreages in the lower Rio Grande, Presidio, and El Paso Valleys of Texas are being sprayed and dusted with DDT to determine whether the pink bollworm can be controlled sufficiently to reduce the hazard of further spread to new areas and prevent the necessity of establishing non-cotton zones.

Information has also been obtained on the effectiveness of DDT-pyrophyllite dusts of various concentrations against a number of other important cotton insects. In the formulations used DDT was not effective against the boll weevil or the cotton leafworm, and caused an increase of the cotton aphid and the common red spider. It was effective against the bollworm, the cotton flea hopper, and several other mirids, stinkbugs, the onion thrips and tobacco thrips, and the beet armyworm on cotton.

In laboratory tests 2.5- and 5-percent DDT dusts caused low mortality of the boll weevil, but 10-percent dust approached calcium arsenate in effectiveness. In field plots several applications of 5-percent DDT dust failed to control the boll weevils and 2.5 percent added to calcium arsenate did not increase the mortality or the yield of cotton so much as did the calcium arsenate treatment. Plots dusted three or more times with as high as 8 percent of DDT in pyrophyllite were completely defoliated by the cotton leafworm, and in laboratory tests the median lethal dosage of a water suspension of DDT applied to the dorsa of large leafworm larvae was 206 times the median lethal dosage for the bollworm.

To the bollworm DDT dust was more toxic than calcium arsenate, lead arsenate, basic copper arsenate, or cryolite, in both laboratory and field tests. A heavy poundage of a low-concentration dust was more effective than a light poundage of a higher concentration containing the same quantity of DDT, and the residual effect from a spray (water suspension) was slightly greater than from dusts. The gains in yield were greater than from calcium arsenate when 4 percent and higher concentrations of DDT dust were used. An important

phase of bollworm control with DDT is that large larvae are killed. This has not been true of the insecticides previously used, and timing of applications to catch the newly hatched larvae has been difficult.

The mortalities in laboratory tests and the gains in field plots indicate that DDT will be better than sulfur or the sulfur-arsenical mixtures now used for control of the cotton flea hopper and some of the other mirids, the plant bugs, and stinkbugs that damage cotton. On irrigated cotton in Arizona the yields from fields heavily infested with several species of plant bugs and stinkbugs were increased 42 to 97 percent by dusting with DDT-pyrophyllite-sulfur. However, the tarnished plant bug and some of the other sucking insects were not readily killed. Further experimentation is needed on formulations and methods of application of DDT for control of cotton insects.

The losses caused by aphids following the use of insecticides for the boll weevil and other insects often offset the gains from control of light to medium infestations and discourage the general use of insecticides on cotton. The destruction of the natural enemies by the insecticides, the physiological effect of calcium arsenate on the cotton plant that stimulates the rate of aphid reproduction and maturity of the leaves, and the increase in aphids following the use of nitrogenous fertilizer add to the complexity of the problem. In some experiments three to six dustings with DDT insecticides caused no apparent increase in aphids, while in others the increase was equal or greater than from calcium arsenate. A mixture of DDT and calcium arsenate caused greater increase in aphids than either insecticide used separately. Nicotine added to DDT in pyrophyllite dust gave about the same control of aphids as when used with calcium arsenate.

Chemistry and mode of action of DDT.—Much attention was devoted to investigations on the chemistry of DDT. The chemical composition of technical DDT was determined, and the constituents were isolated for comparative biological tests. None of the other compounds present were equal to *p,p'*-DDT (1-trichloro-2,2-bis-(*p*-chlorophenyl)ethane) in insecticidal effect. Analogs of DDT and other related compounds were prepared for testing. The compatibility of DDT with many insecticides, fungicides, diluents, and fertilizers was studied. Solutions, emulsions, powders, and aerosols containing DDT were formulated for various insecticidal purposes. Specifications were worked out for commercial grades of DDT and for certain DDT preparations. Analytical methods were studied, and a sensitive colorimetric method was developed which is suitable for determining small amounts of DDT such as occur in spray residues, waters from DDT-treated areas, and tissues of insects exposed to DDT. An investigation of the amounts of DDT retained by fruits, vegetables, and foliage is in progress. Experiments on methods of removing DDT-spray residues from apples were carried on in cooperation with the Bureau of Plant Industry, Soils, and Agricultural Engineering. A double-spray apparatus was developed for applying DDT emulsions or suspensions.

Studies of the mode of action of DDT in the insect body indicate that some of the characteristic symptoms can result from action of the poison on the nerves without involving the central nervous system. Similar nervous symptoms can be produced by a number of other compounds. Tentative conclusions have been reached regarding the pos-

sible relationships between chemical constitution of the DDT molecule and the toxicological effect. This compound can penetrate various regions of the integument of the insect, and one ten-millionth of a gram applied in oil to the back of a fly is sufficient to kill it. DDT in certain highly volatile solvents may remain fluid for long periods when applied as drops to various surfaces.

TESTS OF OTHER INSECTICIDAL MATERIALS

The search has continued for new insecticides and fumigants to replace those that were scarce or not available because of war conditions, and attention has been given to ways of improving the effectiveness of well-known insecticides.

New materials.—A large number of organic compounds of different types were synthesized for testing as insecticides, insect repellents, and synergists for pyrethrum, some of which proved effective in preliminary tests.

A total of 1,658 tests, representing 184 samples of materials, were made on plant-feeding insects during the year. Of these samples, 88 showed toxicity to insects. Studies on new nicotine compounds, made in cooperation with the Eastern Regional Research Laboratory, involved 3,124 tests, with 1,882 samples, on plant-feeding insects. Two materials were highly toxic when combined with nicotine, and two new nicotine compounds were found to be more highly toxic than free nicotine.

Out of 337 samples of new materials evaluated as sprays against houseflies, 19 were found to be toxic; 15 out of 195 samples tested showed synergistic action when combined with pyrethrum; and 15 out of 232 samples proved to be more toxic than borax to housefly larvae.

A new insecticidal material the active principle of which is the gamma isomer of benzene hexachloride was tested on various insects and found to be more toxic than DDT to some and less toxic to others.

More than 20 organic chemicals have been found effective as mosquito repellents, and many of these are now under test in many parts of the world.

Over 300 million 2-ounce bottles of insect repellents have been used by the Allied armies since May 1942, when they were first recommended by the Bureau. Dimethyl phthalate, Indalone (α, α' -dimethyl- α' -carbobutoxy- γ -dihydropyrone), and 2-ethylhexanediol have been used alone and in combination to protect our fighting men principally from species of mosquitoes which transmit disease. It was found that a combination of these three materials was effective for use against malaria mosquitoes found in the United States and was more generally effective on every individual for various mosquitoes and biting flies than was any of these compounds alone. This development has enabled the armed forces to issue a single repellent for the protection of personnel for several hours. When dimethyl phthalate is emulsified and used in the treatment of the outer garments, it gives protection against chiggers between launderings or for almost a month on unwashed clothing. It is not completely effective against ticks, but the undiluted dimethyl phthalate does afford a degree of protection, especially against immature stages.

The United States of America Typhus Commission requested information on a material for repelling the Pacific mite, which trans-

mits scrub typhus. Within a few months entomologists in the Bureau recommended the use of benzyl benzoate for impregnation of clothing as a means of preventing outbreaks of this disease.

For treatment of screwworm-infested animals some progress was made in developing two new smears that contain chlorophenoxathiin. They showed a distinct advantage over smears containing diphenylamine in that the materials did not become hard and crusty on the wound after the benzene in which they were dissolved had evaporated.

The insecticidal principle of *Erigeron affinis* DC., a Mexican plant known to be poisonous to flies and some other insects, was isolated and identified. It was named "affinine." Compounds related to affinine were synthesized for insecticidal tests. Methods were investigated for the extraction of the alkaloid anabesine from the American plant *Nicotiana glauca* Graham. Comparative tests were made with anabesine and the related alkaloids, nicotine and nornicotine, against several species of insects.

Sprays made from the ground stems of a tropical plant, *Ryania speciosa* Vahl, were as effective experimentally as the standard rotenone spray in controlling the European corn borer.

Dust mixtures containing 5, 10, or 15 percent of ground sabadilla seed, with or without sulfur, were inferior to those containing 5 percent of DDT in their initial or residual effects against *Lygus* plant bugs on sugar beets and alfalfa grown for seed.

Rotenone-containing materials.—Tests were made with various dusts that are suitable for diluting cube powder used in dry treatment of cattle for the control of cattle grubs. The most efficient diluents tested were pyrophyllite, Friarite M3 (a volcanic ash), and double-ground tripoli earth. The most economical and effective dusts consisted of 1 part of cube (5 percent rotenone) and 2 parts of the diluent, by weight. Where 3-ounce doses were applied over the backs of the cattle, approximately 90 percent of the grubs were killed. In other tests in which cattle were made to swim for 2 minutes in a vat containing a dip consisting of 96 pounds of cube (5 percent rotenone) per 1,000 gallons of water, 85 percent of the grubs were killed within 9 days.

Continued work with derris resins in oils for control of the California red scale has shown that the effect of the derris varies with the emulsifier used in preparing the spray. Derris adds little or nothing to the toxicity of oils prepared with some emulsifiers and adds much when they are prepared with others. Although the reasons for these differences are not yet understood, more effective use of derris-oil sprays is indicated.

Lumbermen working in tick-infested areas were afforded some protection against the attachment of all stages of the lone star tick when their clothing was sprayed twice daily with pine oil containing rotenone (250 mg. in 100 ml. of oil).

Pyrethrum.—Chemical investigation of the structure of the pyrethrins, the active principle in pyrethrum insecticides, has shown that accepted ideas of their composition must be modified, since so-called pyrethrolone, the alcoholic portion of the pyrethrin esters, is made up of a major component, for which the name "pyrethrolone" is retained, and a considerable proportion of a second compound, called "cinerolone," which contains 1 less carbon atom in the side chain of the molecule. Pyrethrins I and II and "cinerins" I and II have been

prepared from both optically active and racemic pyrethrolone and cinerolone for testing as to their insecticidal value.

Poor results were obtained in tests with pyrethrum dusts against *Lygus* bugs in seed alfalfa in Utah. A dust containing pyrethrum with a synergist appeared promising in preliminary trials against grasshoppers in dense stands of alfalfa.

Other materials used in sprays, dusts, or soil applications.—At Yakima, Wash., the development of an infestation of the Pacific mite was prevented by use of 2 pounds of xanthone per 100 gallons of water, to which was added 1 quart of stove oil and 8 ounces of a commercial spreader, as suggested by the California Agricultural Experiment Station.

The development of an infestation of the Pacific mite was prevented. In addition, it gave a highly satisfactory control of the codling moth. This material has not given good results in less arid areas.

Experiments conducted at Fort Valley, Ga., indicated that propylene dichloride used at half the strength recommended for ethylene dichloride may control the peachtree borer without injuring the tree and at less cost than with the latter material. It seems to be especially effective against borers present in the trees at unusual depths.

Pyrethrum, styrene dibromide, and dichloroethyl ether in oil were all less effective than DDT against the corn earworm. Equally good results were secured when oils of 80–90 and 120–125 seconds Saybolt viscosity were used.

Cryolite was found effective for controlling a webworm in lespedeza. It also continued to provide better control of the sugarcane borer than other materials tested, including DDT, castor-bean extractives, dinitro-*o*-cresol ethyl ether, and potassium fluosilicate. The best control of the yellow sugarcane aphid was obtained with applications of a 4-percent nicotine dust. Potassium fluosilicate appeared to be about as toxic as cryolite to adult white-fringed beetles.

Dusts containing 12 percent of dinitro-*o*-*sec*-butylphenol were more toxic to grasshoppers in dense stands of alfalfa than dusts containing 10 or 12 percent of dinitro-*o*-cresol; both materials, however, were severely injurious to foliage.

In an investigation of a large number of chemical dusts for treatment of seeds to prevent insect damage, 0.1 percent by weight of magnesium oxide gave excellent protection when moisture content of the seed was not over 12.5 percent.

A mixture of 1 part of *o*-dichlorobenzene and 6 parts of fuel oil sprayed at the base of spruce trees containing the hibernating adults of the Engelmann spruce beetle and on the main stems containing immature forms gave excellent results.

Experiments conducted in South Carolina with insecticides against the boll weevil on cotton showed that basic copper arsenate gave about the same control of light infestations as standard calcium arsenate. Both materials were significantly better than iron arsenate (scorodite), magnesium arsenate, potassium fluosilicate, barium fluosilicate, or cryolite, but they also caused heavier aphid populations to develop. None of the specially prepared calcium arsenates with different percentages of soluble arsenic and varying physical properties, combinations of arsenates, or calcium arsenates with adhesives or other additives were superior to commercial calcium arsenate.

When applied to the soil at the rate of 500 pounds per acre to test their effect on plant growth, basic copper arsenate was less toxic to cotton and cowpeas than paris green, calcium arsenate, or lead arsenate. The addition of 5 percent of iron, lead, or copper oxide to calcium arsenate tended to correct the adverse effect of calcium arsenate on plants growing in a light, sandy soil, but the oxides of manganese and magnesium were of little value. A combination of the several oxides was more effective than each used separately, especially in the second year after application.

Afternoon applications of mixtures of calcium arsenate and nicotine gave better control of the cotton aphid than morning applications, but the morning applications gave better boll weevil control, and midday applications were less effective against both insects. Alternate applications of calcium arsenate and mixtures of calcium arsenate and nicotine gave better aphid control when the mixtures were used in the second and fourth applications than in the first and third applications. Owing to low aphid populations, the results of experiments to determine the degree of aphid infestation at which it would be most economical to begin control and the effects of varying aphid populations on the spinning qualities of lint were not conclusive.

Baits and barriers.—Dry bran-sawdust baits were more effective than wet baits against grasshoppers in tests in alfalfa fields in Arizona and grassland in California. Sodium arsenite and sodium fluosilicate were equally toxic, and sodium fluoride and ammonium fluosilicate less so. All baits applied during the season were more than twice as effective in thin alfalfa as in dense stands. In intensive field trials in Arizona early in the 1945 season, bait efficiency was materially increased by using a 1:1 instead of a 1:3 bran-sawdust mixture and 6 instead of 4 pounds of sodium fluosilicate per 100 pounds of carrier. Two quarts of sodium arsenite was also found more effective than 4 pounds of sodium fluosilicate.

Ammonium fluosilicate was as effective as sodium fluosilicate in bran baits for Mormon cricket control. Baits containing more of the coarse fractions of sawdust gave better control than those containing more of the finer fractions. Wholewheat flour-sawdust baits did not give consistently high kills under all conditions.

Tests have shown that 8 percent of dinitro-*o*-*sec*-butylphenol or dinitro-cyclohexylphenol, in pyrophyllite with 5 percent of oil, was about as effective a chinch bug barrier as a similar dust containing dinitro-*o*-cresol, and gave complete protection of corn against bugs crawling from adjacent wheat. The dinitro-*o*-cresol dust gave complete control even though it was 3 years old. An improved "hydroformers bottoms," a byproduct of oil refining, was found satisfactory as a barrier against migrating chinch bugs.

Wrappings coated or impregnated with either an acrylamide or a trichlorobutyramide prevented insect entrance into packages of cereals.

Fumigants.—Tests in a commercial flour mill showed that fumigation of machinery units every 3 weeks held the insect infestation at a low enough level to insure the production of insect-free flour, at a relatively low cost. In tests of various chemicals as possible substitutes for standard fumigants likely to be scarce owing to war conditions, a mixture of equal parts of acrylonitrile and carbon tetrachloride was found satisfactory for local fumigation of milling machinery. Car-

bon tetrachloride and various mixtures of carbon tetrachloride with ethylene dibromide or trichlorethylene gave promising results as grain fumigants.

In experimental trials serious infestation of wheat in Ever-Normal Granary type steel bins was prevented either by fumigating annually in September or by painting the exterior walls and roofs white to reflect the heat and keep the grain cool.

At Fresno, Calif., certain packages of prunes packed for the armed forces, which were tested for "insect proofness," did not become infested with the Indian-meal moth, the saw-toothed grain beetle, or the confused flour beetle after being exposed to infestation by these insects for 41 days. In tests of fumigants introduced into individual packages 4 ml. of ethyl or isopropyl formate gave incomplete kills of larvae in such packages, and 5 ml. gave complete kills.

Preliminary tests indicate that packing-line fumigants may be more effective when applied to the top of the fruit in the filled boxes than when applied to the bottom of the empty boxes, as at present. A mixture of equal parts of acrylonitrile (vinyl cyanide) and carbon tetrachloride killed all larvae of the raisin moth and adults of the saw-toothed grain beetle at the low dosage of $\frac{1}{4}$ pound per 1,000 cubic feet when exposed for 15 hours at 68° to 82° F. At a lower temperature a dosage of only 2 ml. of this mixture killed all test insects and eggs in solid-fiber, 25-pound boxes of raisins (0.41 cu. ft.) packed on Government order. No hydrocyanic acid was found in analyses of raisins exposed to acrylonitrile.

Cotton-mopping mixture.—Although cotton growers in the Southeastern States continue to mop with the "1-1-1 mixture" (calcium arsenate 1 pound, molasses 1 gallon, and water 1 gallon) for boll weevil control, especially for light infestations, experiments on mopping entire fields again failed to give protection throughout the season. Thirty-nine fields in South Carolina, Georgia, Mississippi, and Louisiana, containing 138 acres, were mopped three times at weekly intervals. Plans were made to dust half the area of each mopped field with calcium arsenate for comparison, but weevil populations were so low that dusting was required on only five of the South Carolina fields. The average increase in yield was 56 pounds of seed cotton per acre from mopping and 264 pounds from mopping followed by dusting.

In the other three States there was no average gain from mopping. As in previous experiments, mopping caused considerable reduction of weevils early in the season but did not prevent a build-up to injurious numbers as the season progressed and cannot be depended upon when control by an insecticide is needed. Other tests showed that citrus molasses, a waste product of the juice industry, could be substituted for the critical blackstrap molasses in the mopping mixture.

Termite and decay preventives.—In accelerated laboratory tests with a large number of materials conducted in Mississippi in cooperation with the Southern Regional Research Laboratory, copper naphthenate in Stoddard's solvent (1 percent of metallic copper based on weight of goods) combined with 15 percent of creosote gave the best protection to fabric when the treated cloth was exposed to attack by subterranean termites. Such a treatment is suitable for sand bags and certain other fabrics used in military operations. Copper naphthenate in kerosene oil (2 percent of metallic copper) gave the best protection for several months to pine ammunition-box lumber; the lumber was

dipped for 3 minutes, dried, and then exposed to attack by subterranean termites. Copper pentachlorophenate dissolved in methyl alcohol (0.5 percent of metallic copper) gave poor protection to lumber even after a short period of test. The methyl alcohol proved to be a poor solvent for this compound. Copper pentachlorophenate (1 percent of metallic copper) dissolved in butyl Cellosolve gave protection to treated fabric against subterranean termites and decay for 7 months.

In cooperation with a commercial company and the Louisiana State Highway Department, mahogany plywood panels treated with copper pentachlorophenate are under test in the ground against subterranean termites and decay, as well as in salt and brackish water against marine borers and fouling organisms.

Chemical analyses.—The chemical analytical service for the various Divisions of this Bureau was continued. More than 1,000 samples of insecticides and of fruits, vegetables, and other products containing residues were analyzed.

USE OF BIOLOGICAL CONTROL METHODS

IMPORTATIONS OF BENEFICIAL INSECTS

During the past year special emphasis has been placed upon the collection and forwarding of parasites of the vegetable weevil and the cotton boll weevil from South America. The shipments of vegetable weevil parasites assembled in Uruguay and Argentina consisted of 1,465 parasitized host larvae and 1,544 cocoons containing *Porizon* spp. and 244 cocoons containing *Triaspis* sp. This material was forwarded directly to the California Agricultural Experiment Station for rearing and field release.

Shipments of boll weevil parasites from Peru consisted of 24 consignments, totaling 28,874 adults, of *Triaspis vestitica* Vier., for direct release in infested fields in Texas and other States.

The parasite-receiving station at Hoboken, N. J., was closed late in 1944 for an indefinite period.

A new project, the biological control of the Klamath weed, was initiated in the fall of 1944 in cooperation with the California Agricultural Experiment Station. Large-scale shipments of *Chrysolina hyperici* Foerst. and *C. gemellata* Rossi, both of which are leaf-feeding beetles, and *Agribus hyperici* Creutz, a root borer, were received from Australia through the courtesy of the Council for Industrial and Scientific Research. These species are being tested upon several economic crops, and the first field releases of *C. hyperici* have already been made in northern California.

COOPERATION WITH STATE, TERRITORIAL, AND FOREIGN ORGANIZATIONS

In cooperation with the Puerto Rico Agricultural Experiment Station shipments of the following sugarcane borer parasites were made from Brazil to that Island: Larval parasites: *Theresia diatraeae* Brethes, 5,425; *Parthenoleskia parkeri* Towns., 67; and *Iprobracon amabilis* Brethes, 108 puparia. Egg parasites: *Telenomus alecto* Cwf., 1,250; and *Trichogramma* sp., 2,500 parasitized eggs.

In addition to the cooperative work with the California Agricultural Experiment Station on vegetable weevil parasites, consignments of *Trichopoda pennipes* L., a parasite of the squash bug, were reared and

forwarded to the Utah and Washington Agricultural Experiment Stations and of *Ephialtes caudatus* Ratz., a codling moth parasite, to the New Jersey Agricultural Experiment Station. Arrangements were made for shipments of the following parasite material to foreign countries: Cultures of *Bacillus popilliae* Dutky and *B. lentimorbus* Dutky, disease-producing organisms attacking the grubs of the Japanese beetle, to Australia; a consignment of *Macrocentrus ancyllivorus* Roh., a larval parasite of the oriental fruit moth, to Brazil; and a shipment of four species of mealybug parasites to Russia.

METHODS FOR BREEDING ORIENTAL FRUIT MOTH PARASITE IMPROVED

The new method of producing the important oriental fruit moth parasite *Macrocentrus ancyllivorus* Roh. from the potato tuber worm was further developed for use under eastern conditions during 1944. Breeding throughout the year was found feasible. With a parasitization rate of 60 percent, 2,000 parasites, including an eightfold increase of females, per 10-pound tray of potatoes may be obtained in each turn-over. Shipments of *M. ancyllivorus* for liberation and breeding stocks of it and the tuber worm were made to interested State agencies, as heretofore. In New Jersey orchards in which 3 *M. ancyllivorus* females per tree were liberated suffered less oriental fruit moth injury than those in which a smaller number were liberated and 52 percent less than those in which none were liberated. Results in Ohio under conditions of drought and a light infestation were not so promising.

NATURAL ENEMIES CONTROL COMSTOCK MEALYBUG

Satisfactory natural control of the Comstock mealybug is being maintained in infested apple orchards in northern New Jersey and southern Ohio by the parasites introduced by this Bureau, and the formerly severe infestations in Delaware and southern New Jersey subsided during 1944 as parasitization became effective. Results were less definite in Connecticut. Two introduced parasites, *Pseudaphycus* sp. and *Allotropa burrelli* Mues., are now dominant and have shown an exceptional ability to persist when the mealybug becomes scarce, and to extend their distribution rapidly. During 1944 over 55,000 *Pseudaphycus* adults were liberated in 16 orchards in Virginia, New Jersey, Delaware, and Connecticut, and nearly 17,000 adults of *A. burrelli* were released in 5 Virginia and 2 Delaware orchards. A secondary cycle of mealybug activity appears to have developed in some of the older infested areas in Virginia, but it is much less damaging than the first, and there are indications that a state of balance is being attained between the insect and its introduced natural enemies, which should prevent or minimize future losses.

CORN BORER PARASITES COLONIZED EXTENSIVELY

Field collections of borers in Massachusetts, Connecticut, and New Jersey, in cooperation with State agencies, provided almost 500,000 adult parasites of 4 species, which were released during the season in 13 States throughout the infested area. Over 500,000 borers were collected from these 3 States to provide parasites for release in 1945. Parasitism of the overwintering borers by 4 imported parasites continued

high in the Eastern States, and a pupal parasite continued to maintain its status near Boston, Mass. Parasitization of the early summer borers was considerably higher than that of overwintering borers, ranging from 15 percent at Burlington, N. J., to 43 percent at Taunton, Mass.

SPRUCE BUDWORM PARASITES STUDIED

Investigations on parasites of the spruce budworm have been initiated. Specialists are studying those in the Rocky Mountain region with the hope that some species not occurring in the East may be found. If any such species are discovered, they will be shipped to the Eastern States for colonization. Similarly, if eastern parasites not occurring in the West are found, attempts will be made to establish them in budworm infestations in the western areas.

DISTRIBUTION OF MILKY DISEASE CONTINUED

By the close of 1944 the cooperative program for distributing the milky disease of Japanese beetle grubs had resulted in the treatment of more than 66,000 sites in 86 counties in 12 States and the District of Columbia. In addition, the Bureau had treated 9,033 acres of turf on 128 Government-owned reservations in 7 States and the District of Columbia. In 1944 alone 2,257 acres of Government property, largely on Army airfields, were treated by the Bureau, and approximately 7,258 acres of private property in 9 States and the District of Columbia were treated by the Bureau in cooperation with State agencies. This program is being continued, with special reference to the treatment of Army and Navy establishments. The results of this program continue to be favorable.

NEMATODES OF WHITE-FRINGED BEETLES EVALUATED

The results of propagation and dissemination of parasitic nematodes in areas infested by white-fringed beetles do not suggest that nematodes will become a major factor in beetle control, or that there is any practical way of artificially increasing their effectiveness.

PROGRESS MADE IN DISEASE-VECTOR STUDIES

Final readings have been made on a sufficient number of transmission tests at Chattanooga, Tenn., to indicate strongly that the phony peach disease is not spread by soil-inhabiting insects. Data collected in surveys for possible vectors have pointed toward a small group of twig-feeding leafhoppers as likely to include the vector.

The finding of the destructive elm virus disease in the western Mississippi Valley and the encroachment of the Dutch elm disease into elm virus areas where heavy populations of elm bark beetles already exist stimulated interest in these two destructive diseases of elm. Additional funds were provided for increased investigations on the elm virus disease, and the Bureau's Morristown (N. J.) laboratory was moved to Columbus, Ohio, where studies on the vectors of both diseases could be combined. It has been found that DDT is very effective against the group of elm insects suspected of transmitting the virus-disease organism, and large-scale control projects are being

conducted at Columbus and at Kansas City, Mo., to determine whether valuable trees can be saved by control of the suspected vectors.

Two large-scale experiments on control measures for the vectors of Dutch elm disease are under way. One involves the destruction of beetle-breeding material within the area to be protected, while the other aims at controlling the beetles through chemically treated trap trees.

MORE INSECT-RESISTANT PLANTS DEVELOPED

Additional lines of corn resistant to the European corn borer have been discovered, and those previously found are being utilized, either directly as inbreds or as parents in breeding programs carried on by State and Federal plant breeders, to intensify resistance or transfer it to susceptible but otherwise desirable agronomic lines. It has been determined that the primary point of larval establishment in the whorl stage of plant growth is in the wet basal area of the partially unfurled leaves, and that the presence of pollen in the tassel buds, the axils of the leaves, and similar places after shedding is associated with high rates of larval survival.

Earworm-resistant dent corn R30 is being used in commercial crosses, and resistant sweet corn 471U6 has very promising commercial prospects. A number of field-corn lines adapted to southern localities show promise of carrying earworm resistance.

In California Big Club 43 and Poso 42, two wheats being increased for commercial release, continued to maintain their resistance to hessian fly infestation. Advances toward commercial release of wheats highly resistant to this fly, as well as to diseases, in the main winter-wheat belt were made in cooperation with Department and State experiment station wheat breeders. Release by 1948 of fly-resistant wheat is anticipated.

Alfalfa plants growing in alkaline soil supported greater populations of aphids than plants in the same field growing on more acid soil. Liming of soil resulted in a large increase in aphid populations, and the calcium content of aphid-susceptible plants was found to be considerably greater than that of resistant plants. Rooted alfalfa cuttings of a number of field selections of the variety Ranger (A-136) showed a high degree of aphid resistance in the greenhouse.

A comparison of the aphid population on 65 inbred lines and 22 commercial varieties of cotton shows that considerable progress has been made in selecting and breeding for aphid resistance, and that productiveness and quality of lint has been maintained. In cooperation with State and Department cotton geneticists, studies to determine the inheritance of pilosity of leaves, which is a factor in aphid resistance, were made in 10 inbred lines of cotton and in the first-generation hybrids. Samples of cotton from 150,000 self-fertilized bolls were examined for percentage of lint, uniformity, and strength of fiber to select those that were to be retained for future breeding work. The development of aphid-resistant or aphid-tolerant cotton is slow, but promises good returns.

An additional variety of cane resistant to the sugarcane borer has been recommended to the plant breeders. Eight promising varieties not yet released by them for commercial use appear to be resistant to borer injury.

PROGRESS IN THE FIELD OF BEE CULTURE

PUBLIC POLLINATION CONSCIOUS

Probably at no time has the public been more conscious of the need for bees to serve as pollinators than during recent years. In their efforts to meet war-production goals seed producers, orchardists, and producers of other insect-pollinated crops have been brought to a greater realization than ever before, not only of their dependence on pollinating insects, but also of the fact that the honeybee is the only pollinating insect that can be obtained in any desired numbers to be placed where needed when needed.

HONEYBEE MOST IMPORTANT ALFALFA POLLINATOR

Cooperative studies on alfalfa pollination in Utah gave further proof that the honeybee is now the most important pollinating insect of alfalfa in that State. Although the *Megachile* bee is of prime value as a pollinator of alfalfa, this insect was found to be so widely dispersed and so little concentrated in any one area that its collective efforts cannot be depended upon for pollinating the commercial alfalfa seed crop. *Nomia*, another bee effective as an alfalfa pollinator, was found in abundance only near its nesting places, and so is not important throughout any wide area. This is fortunate for the honey producer, because on occasions *Nomia* trips alfalfa blossoms so rapidly and consistently as to deprive honeybees of a chance to collect nectar, since the latter can gather nectar only from untripped blossoms.

FURTHER ADVANCE IN ARTIFICIAL INSEMINATION OF QUEEN BEES

Prior to 1944 queen bees artificially inseminated rarely started egg laying sooner than 30 days after emergence. This time lag was reduced to an average of 15.3 days during the past season by giving 2, 3, and 4 inseminations of 2.5 mm.³ of sperm at 2-day intervals during the first 10 days after emergence, using carbon dioxide as an anesthetic. Of 72 queens inseminated by this method, 55 laid eggs.

WORK ON RESISTANCE TO AMERICAN FOULBROOD ACCELERATED

Studies on resistance to American foulbrood are being materially accelerated through recent progress in the technique for the artificial insemination of queen bees. In 34 colonies headed by artificially mated queens from 2 inbred and cross-bred resistant strains, only the brood of 4 inbred queens of 1 of the strains showed any sign of disease and these recovered, making the season's record for all colonies 100 percent resistance. In colonies headed by naturally mated queens of the sixth generation of the latter strain, 28 percent became infected but recovered, while 39 percent showed no infection. For the other strain, which was tested in the seventh generation, 5 percent of the colonies recovered after infection, and 50 percent showed no disease. The ninth generation of a third resistant strain showed resistance in 62.5 percent of the colonies tested, and for the colonies of a new strain being tested in the first generation of two lines the figures were 70 and 86 percent. The artificially inseminated inbred queens and some of the hybrids produced brood of poor quality and did not develop strong colonies. A few of the artificially inseminated hybrid queens

were outstanding as regards quality of brood and production of honey. European foulbrood was again present in colonies headed both by naturally and artificially mated queens. One hundred and seventy-five queens of resistant stock were distributed to State agencies.

A NEW ANTIBIOTIC

An antibiotic has been discovered that is produced by *Bacillus larvae*, the organism causing American foulbrood of honeybees. In petri-dish cultures inhibition has been obtained with it against *Brucella melitensis*, *B. abortus*, *B. suis*, *Aerobacter aerogenes*, *Escherichia coli*, *Staphylococcus aureus*, *Bacillus alvei*, *B. orpheus*, and bovine and human strains of *Mycobacterium tuberculosis*. It is not extracted or destroyed by treatment with ethanol, methanol, butanol, ether, acetone, pyridine, or chloroform. It does not dialyze through a colloidin membrane. Its potency is not lost when scale suspensions are pasteurized for 10 minutes at 65° C. Autoclaving at 15 pounds for 30 minutes completely destroys it.

Following the discovery that the enzymes produced by *Bacillus larvae* hydrolyze milk, a flash test for field use for American foulbrood has been developed. An American foulbrood scale is placed in milk at 70° C. If the disease organism is present, curdling occurs in less than 1 minute. Hydrolysis of the curd then begins and is usually completed within 10 minutes, leaving a yellow serous residue. The total cost of testing equipment should be less than \$1.

BEE POISONING

Over 850 samples, mostly of plant blossoms, were received from State authorities in Utah for arsenic determination. The highest arsenic trioxide content for blossoms was found in samples collected in localities where smelters are located or in more remote localities in the path of drifting smelter smoke. This points to smelter fumes as the source of the arsenic, although the use of insecticide sprays and dusts on fruits and vegetables may also have been a contributing factor in certain cases.

That the action of insecticide poisoning on a colony may be delayed for 2 or 3 months was shown by the fact that unconsumed poisoned pollen was found in a hive 9 weeks after being collected. Arsenical dusts can drift more than 2 miles, as evidenced by deposits found on petri dishes exposed at different distances from fields being dusted. However, bees collected 1½ miles from a dusted field in line with the drift did not contain abnormal amounts of arsenic. In Arizona bees collected on cotton dusted 16 days previously contained lethal amounts of arsenic.

Observations in Texas on the effect on honeybee colonies of experimental airplane dusting of DDT to control cotton insects produced no observable injury. Encouraging as these results are, more extensive observations over a longer period will be necessary before arriving at a final conclusion.

NEW EVIDENCE ON SEX DETERMINATION AND HYBRID VIGOR OF HONEYBEES

Evidence was obtained from two generations of sibling individual matings that the sex-determination mechanism in the honeybee may

be the same as in *Habrobracon*. In each case one-half the brood in the first generation was highly viable and one-half poorly viable. In the second generation sisters of poorly viable brood produced one-half poorly and one-half highly viable brood. These results are to be expected if sex is determined by a series of multiple sex alleles, as in *Habrobracon*. The same results would be expected, however, from a series of alleles which were lethal when homozygous but viable when heterozygous.

In honey-production tests involving 11 lines of stock, colonies known to be hybrid from their color rated highest. These results indicate that hybrid vigor may be utilized to improve production. Certain of the lines also showed pronounced brood-rearing capacity.

POLLEN-SOYBEAN FLOUR SUPPLEMENT PROVES ITS VALUE IN FURTHER TESTS

Feeding pollen and soybean flour to unprotected colonies in winter resulted in better colony development early in the spring than did the generally accepted method of heavily packing colonies for winter without supplemental pollen feeding.

In limited tests bees fed clover pollen supplemented with soybean flour reared more brood than did those fed unmixed ryegrass, star-thistle, partridge-pea, and clover pollen alone, the figures being 32,400 bees (over 6 pounds) per pound of supplement against 2,350 bees (about $\frac{1}{2}$ pound) per pound of unmixed ryegrass pollen.

SURVEYS INCREASE KNOWLEDGE OF PEST DISTRIBUTION AND ABUNDANCE

ADDITIONS TO INSECT PEST SURVEY RECORDS

Additions to the permanent files of the Insect Pest Survey comprised 23,000 current reports on domestic insects and 700 on foreign species. Of these, about 3,000 were furnished by collaborators and Bureau field personnel; the remainder became available as a result of the pest survey conducted in the vicinity of ports of entry. These reports provided many valuable new records of insect distribution and host-plant relations, and brought the total number of notes now on file to over 453,000. Records on 80 genera and 200 species not previously included were added to the file of domestic insects.

SPECIAL SURVEY IN VICINITY OF PORTS OF ENTRY

The survey of the more important food crops growing in the environs of ports of entry and international airports on the Pacific, Gulf, and Atlantic coasts and along the Mexican border for introduced plant pests, commenced in June 1943, was continued during the year. There were submitted to specialists for determination 11,751 lots of insect material and 1,626 plant pathological specimens.

The material submitted included several insects known to be of economic importance in foreign countries and heretofore unknown in the United States. The European mite (*Eriophyes peucedani* Can.) was discovered damaging the seed heads of carrot in California, and two lepidopterous insects—*Lineodes vulnifica* Dyar, a Mexican and Central American species, and *Moodna bisinuella* Hamp., a Mexican species—were found in Texas, the former on pepper and the latter in the stalks and ears of green corn.

Insects previously unknown include the moth *Keiferia* n. sp., whose larvae were discovered mining the leaves of eggplant in Texas, New Mexico, and California, and a whitefly, *Aleurocybotus* n. sp., collected on rice and milo maize in California. New distribution records for insects known to occur in limited areas in the United States are as follows: The sweetpotato weevil (*Cylas formicarius* subsp. *elegantulus* (Summers)), found in South Carolina in seaside morning-glory; the lesser clover leaf weevil (*Hypera nigrirostris* (F.)), reported from California on clover; *Chilo loftini* Dyar, discovered in California infesting rice, milo maize, corn, and sugarcane; *Gnorimoschema gudmannella* (Wlsm.), found in Texas in bell pepper; and the scale *Pollinia pollini* (Costa), presumed eradicated in California, rediscovered in Sonoma and San Diego Counties on olive. Insects found infesting new host plants include *Gnorimoschema plaesiosema* (Turner), recorded in California since 1926 and in Louisiana since March 1944 infesting *Solanum nigrum* L. (nightshade), reported in May 1945 boring in the stems of potato plants in Louisiana.

Several plant pathogens not heretofore known to occur in the United States were found during the course of the survey. Plant diseases reported for the first time include *Heterosporium betae* Dowson, a leaf-spot fungus of beet in Germany, on beet and mangel beet in the State of Washington. New distribution records include *Oidium mangiferae* Berthot, a tropical fungus previously reported from Florida infecting *Mangifera indica* L. (mango), discovered on the same host in California. A number of plant pathogens were collected on new hosts, among which were two from the State of Washington—*Taphrina bullata* (Berk. and Br.) Tul. on pear, and *Marmor cucumeris* var. *vulgare* Holmes (cucumber-mosaic virus, typical strain) on tomato.

ORIENTAL FRUIT MOTH SURVEY IN WESTERN STATES

The cooperative Federal-State survey for the oriental fruit moth during the spring and summer of 1944 was confined principally to important fruit areas and centers of distribution in the States of Arizona, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Washington. Emphasis was placed on trapping the moths, twig inspection being conducted incidental to trap inspection. The moth was found for the first time in five counties in Colorado and in one county each in Utah, Idaho, and Arkansas. In order to obtain further information on the distribution of this pest, steps were under way to resume the survey in June 1945 in Colorado, Idaho, Montana, Oregon, Utah, and Washington.

POTATO TUBER WORM

The potato tuber worm survey, requested by the Central and Western Plant Boards and conducted for the last 3 years in cooperation with the State departments of agriculture and agricultural experiment stations, has been completed in all States except Missouri and Iowa.

On the basis of infested material originating from local sources, the potato tuber worm was found, and identified by specialists, in 23 States, as follows:

Alabama.
Arizona.
Arkansas.
California.
Colorado.
Delaware.
Florida.
Georgia.

Indiana.
Louisiana.
Maryland.
Mississippi.
Nebraska.
New Jersey.
North Carolina.
Ohio.

Pennsylvania.
South Carolina.
Tennessee.
Texas.
Virginia.
Washington.
Wisconsin.

Except in Tennessee, where the sole find was in tobacco growing in the field, and Georgia, where the infestations were found in tobacco and wild host plants, all collections were made from potato leaves, stems, stalks, or tubers in the field, or from potato storages of local origin.

THE GOLDEN NEMATODE

The golden nematode, long a destructive pest of potatoes in northern Europe, has been known to be present in Nassau County, Long Island, N. Y., since 1941. In order to determine whether other centers of infestation might be present elsewhere in important potato-growing districts in this country, a Federal-State survey was begun in June 1944 and continued until September, which covered the chief potato areas of 19 northern States east of and including the Red River Valley of Minnesota and North Dakota. Inspections were made at 1,480 locations in almost 50,000 acres. No golden nematode was found, and indications are that no widespread or long-established infestation is present outside the small infested area in Nassau County. At the end of June 1945 an intensive survey in cooperation with New York State was begun to determine the extent of the infestation on Long Island.

OTHER VEGETABLE INSECTS

Special emergency surveys of insects that attack vegetables and their control requirements have been conducted, in cooperation with State workers, industry, and other agencies, in an effort to insure the distribution of insecticides to localities or districts where they are most needed.

CEREAL AND FORAGE CROP PESTS

In 1944 the European corn borer was found for the first time in Kansas, Nebraska, and Tennessee and in a considerable number of counties outside the territory previously known to be infested in 10 other States. Estimated losses to corn caused by the borer in 1944 totaled about \$22,700,000, over \$20,000,000 in field corn and over \$2,500,000 in sweet corn. In the eastern part of the infested area infestations were generally lower than in 1943, while farther west in the Corn Belt, especially in Illinois and Iowa, the borer was much more abundant in 1944.

Heavy populations of the corn earworm developed in 1944 on late corn in central and southwestern Illinois, central Missouri, and Nebraska. Moderate damage to corn was reported from Georgia, Tennessee, Kentucky, and New Jersey, and only light damage from New York. Corn was damaged severely near Logan, Utah, and Phoenix, Ariz., and infestation was heavier than usual in sweet corn at Weslaco, Tex. Soybeans in Virginia and North Carolina and peanuts in Georgia were severely damaged.

A Federal-State survey in the fall of 1944 revealed greater numbers of chinch bugs in hibernation, especially in the Corn Belt States, than had been present in any year since 1934. Moderate to severe or very severe infestations were found in northeastern Arkansas, west-central Indiana, almost all of Illinois, southwestern Iowa, eastern Kansas, north-central, western, northeastern, and southeastern Missouri, southeastern Nebraska, and northeastern Oklahoma. Lighter infestations were reported in other areas of these States and in North Carolina and Ohio. The serious damage in prospect for 1945 was largely prevented by continuous cool wet weather during the spring and early summer. Spring weather conditions in the Southeastern States were more favorable to the bugs, and severe infestations developed, especially in North Carolina.

Hessian fly infestations at harvesttime, 1944, were generally low throughout the winter-wheat belt, although moderate to heavy infestations developed in southern Nebraska, north-central and northeastern Kansas, southern Wisconsin, and southwestern North Dakota.

The grasshopper infestation remained generally at a low level in 1944; however, there were several important shifts in economic populations. Substantial increases occurred in Montana, Wisconsin, and Wyoming, and slight increases were noticed in Arizona, Colorado, Oklahoma, Texas, Utah, and Washington. There were significant decreases in Kansas, North Dakota, and South Dakota. Early season weather was unfavorable to the development of grasshoppers. Late summer and fall months, however, were favorable and to some extent offset the retarding influence of the earlier inclement weather.

Aphid populations were generally low on alfalfa in the Antelope, Santa Clara, and Sacramento Valleys in California and on fall (1943) annual legumes sown for seed in Oregon. A severe outbreak of the velvetbean caterpillar on peanuts, soybeans, velvetbeans, and cowpeas developed in the South Central and Southeastern States. Severe damage to corn by flea beetles and much corn wilt were reported in northwestern Ohio and parts of Indiana late in the summer of 1944.

Loss from insect injury to the alfalfa-seed crop in Maricopa County, Ariz., in 1944 approximated \$326,000. The acreage of hairy vetch grown for seed in Oregon has been reduced from about 125,000 to 50,000 acres, principally because of losses resulting from infestation by the vetch bruchid.

An estimated loss of over \$3,000,000 was caused by the sugarcane borer in Louisiana in 1944. An increase of 1 percent in sugarcane joints bored caused a loss of 77 pounds of sugar per acre.

The sugarcane beetle was somewhat more abundant than for the past several years but was not very injurious. The yellow sugarcane aphid caused heavy injury in some undusted fields, as well as in some fields that had been dusted with cryolite for control of the borer. The West Indian sugarcane fulgorid was found for the first time in several counties of southern Louisiana and Mississippi. Much of the stand of late-planted sugar sorghum in test fields in Louisiana was destroyed by the lesser cornstalk borer. The West Indian sugarcane mite was found for the first time in several Florida sugarcane fields.

FOREST AND SHADE-TREE INSECTS

In June 1945 the spruce budworm was found to be generally distributed throughout the Adirondack area in New York and the spruce-fir

area in Vermont. Most of the infestation, by previous standards, was light, although defoliation was noticeable in a few places. If favorable conditions for increase of the insect occur in 1946, considerable defoliation may result. Surveys in New Hampshire and Maine have revealed only an occasional spruce budworm larva.

The outbreak of the Engelmann spruce beetle in Colorado continued unabated, killing over 1 billion board feet of Engelmann spruce in 1944, and bringing the total loss of timber to approximately 2 billion board feet during the last 3 years. Extensive surveys showed the infestation to be increasing in area and severity. Infestations were found on the Dixie National Forest in Utah and the Holy Cross National Forest in Colorado, in addition to those reported last year. The most severe infestation occurs on the White River National Forest, where 60 percent of the merchantable stand, or 1,783,650,000 board feet, has been killed. Infestations on some of the other National forests have the potentiality of reaching the magnitude of the White River outbreak. Already 10 percent of the spruce, or 5 percent of the timber, in Colorado has been killed.

The discovery that the Engelmann spruce beetle hibernates beneath the bark at the base of the trees during the second winter, a habit unknown to closely related beetles, has an important bearing on control methods. The information on control methods and life history is being used in an attempt to combat outbreaks on the Dixie and Gunnison National Forests. On the White River, Grand Mesa, and Routt National Forests the outbreaks are beyond control, but an attempt will be made to prevent the spread from these areas to other spruce forests. To carry out such a program will require a survey of all the spruce forests to detect incipient outbreaks and continuation of life-history and control studies as a basis for protecting the spruce timber from the ravages of this beetle.

COTTON INSECTS

The early season abundance of boll weevils and other insects, combined with a late planting season and favorable weather for insect development during the early summer, indicated severe insect damage to cotton for 1944. Fortunately, conditions were so changed by hot, dry weather during the critical period of insect development that losses were the lowest in recent years. This changing picture of insect abundance and need for insecticidal control was clearly shown by current weekly information obtained through the emergency cotton-insect survey. With the cooperation of farmer crop reporters, 4-H Club members, vocational agricultural teachers and students, and other State and Federal agencies, over 40,000 fields were examined for insect abundance. This information proved of value to entomologists, county agents, and others in furnishing growers timely advice on the need for controlling insects and conserving insecticides, to Government agencies in making allocations, and to industry in the distribution of insecticides to the areas where most needed. The survey information also enabled the prompt diversion to other crops of materials, such as nicotine, which were in limited supply. The experience gained by farmers and farm youth in recognizing insect damage by making infestation records in their fields should be of great educational value in the more efficient use of control measures.

The damage caused by the boll weevil in 1944 was the least for any year since 1911. The reduction from full yield was estimated by the Bureau of Agricultural Economics at 3.9 percent, and the average gain in the plots dusted with calcium arsenate at Tallulah, La., was 42 pounds of seed cotton per acre as compared with an average of 299 pounds for the last 25 years. The unfavorable conditions for weevils and the favorable conditions for cotton resulted in the highest yields per acre ever recorded in the United States.

PESTS OF MAN AND ANIMALS

Special efforts have been made to assemble and develop new information on the mosquitoes of the Northwestern States and Alaska for publication by the Department.

The screwworm survey, which was initiated in 1943, has been continued with the cooperation of the State agencies concerned. From information obtained in this survey it has been possible to detect early infestations of animals, to aid in the proper distribution of critically needed chemicals, and to advise livestock owners on the use of the approved methods and materials for treatment and prevention of screwworm infestations. Prompt treatment of animals prevented populations of screwworms from developing, thereby conserving chemicals, labor, and animal products.

INSECT IDENTIFICATION AN AID TO ALL ACTIVITIES

Identifications were made for 59,492 insect samples contained in 30,184 lots received from sources requiring identification for the institution of proper control or quarantine action or in connection with the conduct of experimental work. Thirty percent of the lots represented interceptions in imported products and 16 percent collections made in the course of special surveys to ascertain the distribution of specific pests; 33 percent were from research and control activities of this Bureau and other Federal agencies; 11 percent from agricultural colleges and experiment stations of the various States, Alaska, and the insular possessions; 7 percent from individuals, private agencies, and pest-control operators; and 3 percent from foreign governmental agencies and institutions, mostly in the Western Hemisphere.

In addition to the identifications for the Army and Navy of approximately 6,000 samples of insects and mites involved in human health problems or recovered on aircraft, direct assistance or instruction in insect classification was given many officers of both branches of the armed services.

Twenty-four manuscripts, totaling 891 pages, on the classification of various insects and mites, including mosquitoes, chiggers, ants, and flies producing myiasis in man, were completed and submitted for publication. They are designed to serve as guides for the accurate identification of the special groups treated and to provide names and technical descriptions for new species.

DISSEMINATION OF INFORMATION INCREASED

The results of research, control, and regulatory activities were made available to the public through 19 manuscripts approved for printing

by the Department, 41 approved for issuance by the Bureau in processed form, and 274 approved for outside publication, 93 press and 96 radio items approved for release, and 14 Research Achievement Sheets.

Approximately 639,500 printed publications and 68,700 copies of regulatory material were distributed. The distribution of printed publications increased 58 percent over that of the previous year, owing largely to the great demand for information concerning the control of insect pests of Victory Gardens. In addition, 126,000 copies of the E series, $2\frac{1}{2}$ times as many as during the previous year, and 8,900 copies of the ET series were processed.

The great interest in DDT and the demand for information on that subject is reflected to some extent in the increased number of processed publications prepared for distribution, many of which contained reports of experiments with that material.

CONTROL PROJECTS

SUPPRESSIVE MEASURES APPLIED AGAINST JAPANESE BEETLE

There was a 59-percent expansion in the 1944 Japanese beetle trap-scouting program, with 66,828 traps set compared with 41,993 operated in 1943. This was made possible by the resumption of trap manufacture after a number of seasons when materials could not be procured for this purpose. Thirty-eight thousand scouting-type traps were stamped out from metal on hand. A center for reconditioning, sorting, and storing traps was set up at Frederick, Md., so that they would be closer to the outlying States in which they are used.

A considerably wider area was surveyed, particularly in Florida, North Carolina, and New York. Trapping was again performed in 17 States, but the number of cities was increased to 462, or 301 more than last year. Beetles were captured in 112 localities, in 36 of them for the first time. The new finds comprised collections at 22 points in North Carolina, 7 locations in New York State, 3 in Ohio, at 2 of which solitary beetles were taken, and collections of more than 1,300 beetles at Shenandoah, Va., 6 beetles at Mountain City, Tenn., and 1 each at the Kansas City, Mo., airport, and at Richmond, Vt. Sixty-nine of the trap collections were of a few beetles each, while 43 infestations were of such a nature as to warrant soil treatments or quarantine action.

Since geraniol, one of the essential-oil constituents of Japanese beetle trap bait, could not be obtained for the 1945 trapping, anethole, determined as an equally effective attractant, is being substituted for the scarce product.

At the end of the fiscal year trapping was under way farther south, more extensive work being done in Kentucky and Tennessee than in former years. Military and commercial airports west of the Mississippi River were also included in this program.

Cooperative Federal-State control measures applied at isolated infestations, together with State quarantine action as to certain outlying areas, assured adequate protection from the spread of beetles from those areas. The States completed all the legal action that had been proposed to them, thereby removing the necessity for extending the Federal quarantine to the previously nonregulated areas in those States.

Lead arsenate, at the usual rate of 500 pounds per acre, was applied to a total of 985 acres in 44 localities in 10 States, 920 acres being treated in the fall and 65 in the spring. This is an increase of 94 acres over the previous year's treatments. Extensive areas were treated in Ohio, Illinois, Indiana, North Carolina, Michigan, and New York, where 291, 223, 193, 108, 89, and 66 acres, respectively, received applications of lead arsenate. In addition 7.5 acres were treated in Jacksonville, Fla., 3.5 acres each in Kansas City and St. Louis, Mo., 1.35 acres each in Atlanta and Toccoa, Ga., and 1.75 acres in Mountain City, Tenn.

Notable decreases in infestation were found at Highland Park, Ill., Gallipolis, Ohio, and Waterloo, N. Y., where soil treatments had been made in previous years. Only 10 beetles were captured at Highland Park in the summer of 1944, as compared with 63 in 1943 and 173 in 1942. At Gallipolis, where 329 beetles were trapped in 1943, only 12 were caught in 1944. At Waterloo the captures were reduced from 171 in 1943 to 18 in 1944.

A large-scale field experiment to control the beetle with DDT was undertaken at an established, isolated infestation at Blowing Rock, N. C. A dust consisting of 10 percent of micronized DDT in pyrophyllite was applied as a dry-surface treatment to the soil on approximately 225 acres, and 10,000 gallons of spray mixture containing 1 pound of DDT per 100 gallons was applied to tree and shrub foliage in the same area.

CONTROL OF GYPSY AND BROWN-TAIL MOTHS

Climatic and biological factors favorable for gypsy moth development prevailed during the spring of 1944 and, except in those areas where starvation of the larvae occurred following complete defoliation of their host plants, there was a decided increase in deposition of egg clusters by this insect last summer. Winter killing of the eggs was light and confined to limited localities where extremely low temperatures occurred on at least one occasion. There was some mortality of first-instar larvae due to early hatching of many of the eggs because of unseasonably warm weather in late March and early April followed by a prolonged period of cold and rain. However, from observations at the close of the fiscal year it is estimated that defoliation ranging from 25 to 100 percent will occur in 1945 on at least 700,000 acres, compared with such damage on 250,000 acres during the 1944 season.

Emphasis was placed on use of the sex attractant to trap male moths and on manual types of surveys to delimit the area of infestation and to locate all infestations of sufficient severity to represent an appreciable hazard of natural spread. In cooperation with the State agencies concerned, approximately 16,000 charges of sex attractant were used in trapping surveys embracing more than 5,690,000 acres located within and beyond the known limits of gypsy moth infestation. Manual surveys conducted in New York State in the vicinity of traps at which male gypsy moths were taken resulted in discovery of spread of the contiguous infestation into the eastern portions of Montgomery, Fulton, Warren, and Essex Counties located to the northwest and north of Albany and small isolated infestations in Ulster and Westchester Counties.

Similar surveys in the Pennsylvania area resulted in the discovery of an isolated concentration in Wayne County to the northeast of the main infestation, as well as several small infestations adjacent to the area under State quarantine in Lackawanna and Monroe Counties. Although a male gypsy moth was taken in Englewood, Bergen County, N. J., diligent search in a rather extensive area surrounding this trap site by experts of the State organization failed to disclose any further evidence of the insect.

Control measures included cooperation in extensive experiments with DDT (see p. 15 of this report) in several of the areas most heavily infested with gypsy moth, particularly in Pennsylvania and in the New York-New England section. The applications were made largely from airplanes, although ground spray machines and hand-operated equipment were used in some areas of small size. During 1944 the pest was eliminated from a 20-acre wood lot in Pennsylvania by the application from a biplane of DDT at the rate of 5 pounds per acre. Similar results were obtained in a 5-acre tract in Saratoga County, N. Y.

All control and survey work concerning the brown-tail moth was conducted by the New England States. Very little defoliation or heavy feeding was noticed, except along the Atlantic coast between Boston, Mass., and Brunswick, Maine.

SWEETPOTATO WEEVIL ERADICATION CONTINUED

During the calendar year 1944 eradication activities conducted by the Bureau, in cooperation with growers and State agencies in 29 counties in Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas, resulted in the release from planting restrictions of 2,106 of the 2,431 farms known to be infested at the beginning of the year. Farms are released when no weevils have been found on them during a period of at least 12 months. Eradication of the weevil on all known infested farms in 6 additional counties of Alabama, Georgia, Mississippi, and Texas was completed during the calendar year. Over 35,000 inspections were made in 70 counties of the above-mentioned 6 States, and 631 additional infestations were found, including reinfestations in areas where eradication was believed to have been completed, some reinfestations in commercial-producing areas of 6 counties in 3 States where repeated annual inspection had shown no weevils, and a considerable number of infestations in areas where work has been more recently undertaken.

These reinfestations and new finds indicate spread of the weevil, evidently through increased movement of sweetpotatoes to supply wartime demands for food and seed. A large portion of the sweetpotatoes for commercial shipments are grown in heavily infested areas in Louisiana, and that State has greatly increased its efforts to suppress infestations and thus reduce the hazard of weevil spread. During the year cooperative work was extended into northwestern Florida, where infestations were discovered in commercial-producing sections of 5 counties. Increasing numbers of growers are recognizing the importance of fumigation of plants and seed stock and are adopting this practice.

PINK BOLLWORM INFESTATION INCREASES

Additional infestations discovered in southern and northwestern Texas in 1944, together with new discoveries during the crop season of 1943, continued to create an alarming situation, increasing the threat of spread of the pink bollworm throughout the entire Cotton Belt. Inspection of the 1944 crop revealed newly infested Texas counties as follows: Bee, Caldwell, Coke, Coleman, Jackson, Karnes, McCulloch, Nolan, Refugio, Runnels, San Patricio, San Saba, Scurry, Taylor, Victoria, Wilson, and that part of Live Oak not hitherto infested. Bailey and Cochran Counties, which were released from quarantine early in 1944 because of negative findings for a number of years, were found to be reinfested.

Inspections in quarantined areas in southern Texas showed (1) an increase of infestation in the lower Rio Grande Valley counties, particularly Cameron and Hidalgo, (2) a continued general but light infestation in the Coastal Bend counties, and (3) in the Gulf coast areas of Texas and Louisiana a recurrence of the pink bollworm only in Calhoun County, Tex. A further increase of infestation in the El Paso area was noted, with but little change in the other irrigated valleys of Texas, New Mexico, and Arizona. Light infestations were found in nearly all counties of the quarantined part of northwestern Texas.

A total of 24,629 bushels of trash from regulated areas were inspected, and 58,504 pink bollworms were found. Outside of regulated areas, 57,948 bushels of trash were inspected in Alabama, Florida, Georgia, Louisiana, Mississippi, and Texas. With the exception of Texas, where 30 pink bollworms were found, these inspections gave negative results.

Summaries of the amount and results of the various kinds of inspection are given in tables 1 and 2.

TABLE 1.—Results of inspections for the pink bollworm in regulated areas, crop season of 1944

State	Gin trash		Field		Laboratory ¹	
	Quantity	Pink bollworms	Bolls, blooms, and squares	Pink bollworms	Green bolls	Pink bollworms
	<i>Bushels</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Arizona-----	7, 333	² 16	0	0	0	0
Louisiana-----	303	0	41, 737	0	0	0
New Mexico-----	357	18	0	0	0	0
Texas-----	16, 637	58, 470	³ 1, 104, 445	⁴ 607	9, 164	⁵ 1, 719
Total-----	24, 630	58, 504	1, 146, 182	607	9, 164	1, 719

¹ Bolls collected from 1943 crop.
² Distributed in counties as follows: Graham 1, Greenlee 3, Maricopa 7, Pinal 5.
³ Of these forms, 1,039,571 were squares and blooms inspected in southern Texas counties.
⁴ Distributed in counties as follows: Calhoun 12, Cameron 158, Duval 25, Hidalgo 32, Jim Hogg 1, Jim Wells 356, Kleberg 15, Nueces 8.
⁵ Distributed in counties as follows: Calhoun 4, El Paso 932, Hudspeth 783.

TABLE 2.—*Results of inspections for the pink bollworm outside regulated areas, crop season of 1944*

County and State	Gin trash		Field		Laboratory ¹	
	Quantity	Pink bollworms	Bolls, blooms, and squares	Pink bollworms	Green bolls	Pink bollworms
UNITED STATES						
	<i>Bushels</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Alabama-----	1, 228	0	0	0	0	0
Arizona-----	0	0	1, 575	0	0	0
Florida-----	256	0	² 52, 588	332	³ 34, 703	0
Georgia-----	2, 117	0	0	0	0	0
Louisiana-----	7, 495	0	13, 320	0	0	0
Mississippi-----	1, 908	0	0	0	0	0
New Mexico-----	58	0	0	0	0	0
Texas-----	44, 886	30	148, 725	⁴ 6	6, 752	0
Total-----	57, 948	30	216, 208	338	41, 455	0
MEXICO						
Baja California-----	665	0	0	0	0	0
Sinaloa-----	563	0	0	0	0	0
Sonora-----	34	0	0	0	0	0
Total-----	1, 262	0	0	0	0	0
Grand total----	59, 210	30	216, 208	338	41, 455	0

¹ Bolls collected from 1943 crop.² 15,506 bolls from sea-island cotton and 37,082 from wild cotton. The 332 specimens were from bolls taken from wild-cotton plants.³ From preserved sea-island bolls.⁴ 4 in Refugio County and 2 in San Saba County.

There has been no spread of pink bollworms from wild cotton, as the infestation in wild cotton has been kept low despite difficulties in obtaining labor. Although two and one-half times as many acres were cleaned this year as in 1943, only approximately 65 percent as many plants were removed, owing to unfavorable conditions and previous efforts to prevent development of seed.

STATE AID IN GRASSHOPPER CONTROL

During the 1944 crop season grasshopper control was conducted in 23 Midwestern and Western States. According to estimates compiled by county and State leaders, control operations concluded during the early part of the present fiscal year afforded protection to 4,750,000 acres of crops worth more than \$22,000,000. Over 26,000 farmers participated in the program, spreading 7,600 tons of bait (dry weight). States and counties, with Federal assistance, spread an additional 3,600 tons of bait on rights-of-way and idle lands. Approximately 2,200,000 acres were baited in the combined operations.

Adult and egg surveys made in the fall of 1944 indicate that the grasshopper infestation in 1945 will be of approximately the same extent and intensity as that in 1944. The major control problem is expected in eastern Montana, western North Dakota, and central and western South Dakota, where infestations range from threatening to

severe. The estimated needs for bait in 1945 slightly exceeded the amount used in 1944.

Cool, wet weather, which prevailed over much of the infested area throughout the spring months of 1945, greatly retarded grasshopper hatching and development and delayed control operations. In States other than Arizona, California, and Texas, baiting was not started until June 1, and was carried out on only a limited scale until late in June. By June 23 the total amount of bait (dry weight) that had been mixed for grasshopper control in all States was approximately 1,570 tons. By the end of the month counties and other agencies in 10 States had constructed 52 mixing machines patterned after the batch bait mixer, which was used so successfully in the 1944 control campaign to offset the labor shortage. Nine additional machines were under construction.

MORMON CRICKET INFESTATION REDUCED

Adult-population surveys, made during the summer of 1944 in conjunction with control work in progress and also in areas where special investigations were necessary to observe and delimit infestations, showed a further material reduction in the size of the infested area. As a result of control operations and natural factors, the infested area was reduced from approximately 19,000,000 acres in the fall of 1938 to approximately 295,000 acres in the fall of 1944.

During the 1944 crop season control work was conducted in cooperation with the States of California, Idaho, Nevada, Oregon, and Wyoming. The Federal Government financed the spreading of 1,820 tons (dry weight) of poisoned bait over a total area of about 244,000 acres. Over nearly two-thirds of this area applications were made by airplane and over one-third by power spreaders; a few areas inaccessible to mechanical spreaders were baited by hand. In this way valuable protection was afforded range lands and adjacent crops.

In the spring of 1945 Federally financed control was undertaken in cooperation with the States of Idaho, Nevada, Oregon, and Washington. Control work was begun early in April in Nevada. In the four States 830 tons of bait (dry weight) had been spread by June 30 on 90,000 acres by airplanes, by power spreaders, and by hand. Airplane baiting, which was begun in Idaho on May 30, was responsible for 49 percent of the total acreage baited to June 30.

WEATHER REDUCES 1945 CHINCH BUG POTENTIAL

In 1944 threatening chinch bug populations developed in central Illinois and in a few localities in Indiana, Iowa, Kansas, Missouri, Nebraska, North Carolina, and Oklahoma. Nearly 7,500 farmers in seven States participated in the control program, which was concluded early in the present fiscal year. The farmers used 254,000 gallons of creosote oil and 794,000 pounds of dinitro-*o*-cresol dust, furnished by the Federal Government, to construct and maintain 1,191,000 rods of barrier. County leaders estimated that 566,000 acres of crops were protected and that crop savings amounted to more than \$13,000,000.

Barrier needs for chinch bug control in 1945, based on the large number of hibernating bugs, were estimated at 7,500,000 gallons of creosote oil or an equal number of pounds of dinitro-*o*-cresol dust. However, the cool weather and extremely heavy precipitation which

prevailed in the Central and Midwestern States during the spring of 1945 reduced the potential chinch bug damage in most areas. By June 30 the Federal Government had made available for the use of farmers in the infested States 772,396 gallons of creosote oil and 1,542,900 pounds of dinitro-*o*-cresol dust.

ARMYWORMS AND ARMY CUTWORMS REQUIRE CONTROL

Armyworms and army cutworms did not appear in outbreak numbers in 1944. Small amounts of grasshopper-bait materials were issued to farmers for armyworm control in Arkansas and for army cutworm control in Nebraska and Washington. The total amount of bait used was less than 20 tons.

During the spring of 1945 armyworm and army cutworm infestations developed to the extent that control was necessary in several Central, Midwestern, and Western States. Only in Montana, however, did army cutworms develop in numbers sufficient to threaten large crop areas. This infestation, covering 300,000 to 400,000 acres, was controlled by farmers by timely use of bait furnished by the Bureau. Crop damage was limited to defoliation of 1,500 to 2,000 acres of winter wheat. Where bait was spread during reasonably good weather and where damage was not already too extensive, cutworm populations were reduced sufficiently to allow wheat to resume growth. Grasshopper bait for the control of armyworms and army cutworms was issued to farmers in Arkansas, California, Illinois, Kansas, Missouri, Montana, and Nebraska. The greater part of the 130 tons of bait spread by June 30 was used in Arkansas and Montana.

WHITE-FRINGED BEETLE CONTROL INTENSIFIED

As a result of scouting and inspection to fix the limits of areas infested with the white-fringed beetle during the 1944 season, new infestations were found on 14,411 acres. This pest is now known to occur on a total of 140,000 acres in Alabama, Florida, Louisiana, Mississippi, and North Carolina.

Approximately 1 million pounds of insecticides, in the form of dusts and dilute and concentrated sprays, were applied to an aggregate of 68,702 acres in order to reduce populations at places from which there was danger of spread and on crops the marketing of which presented a hazard. Insecticides and equipment for crop protection were furnished to farmers on condition that the materials be applied under supervision of cooperative-project personnel. Herbicides were applied in railway yards to kill plants and render them unattractive to beetles.

Extensive field tests were conducted to compare the effectiveness of DDT with that of other insecticides and to develop efficient and practical methods for its application. The results indicate this material to be somewhat more effective than cryolite or calcium arsenate. A tractor-mounted combination concentrated-spray and dust machine, which will permit greater and better coverage with considerably less labor, has been developed by the Bureau. Thirty of these machines have been built and are now in operation.

During the winter of 1944-45 nearly 2,000 acres of winter crops, such as oats and legumes, were planted, following recommendations made by the Bureau and by State agricultural agencies for crop prac-

tices to permit profitable farming on heavily infested land during the less destructive stage of the beetle.

Cooperation was extended to producers and shippers of host material and other insect carriers to devise and carry out sanitation practices that would permit the marketing of such products with greater safety and decreased inconvenience. The effectiveness of this cooperation is indicated by the fact that no record of long-distance spread is known.

PEAR PSYLLA SITUATION IN WASHINGTON FAVORABLE

Despite the fact that 403 infestations of the pear psylla were found in the Pacific Northwest in 1944, as compared with 140 in 1943, the known infested area was essentially the same as in previous years, except for some northward extension in British Columbia. The greater number of infestations found was due largely to a marked increase in efficiency in survey methods resulting from the use of sticky boards and bands to trap the insects, in lieu of visual inspection. The additional fact that over three-fourths of the infestations were on doorway or home-orchard trees in four Washington counties (Columbia, Garfield, Stevens, and Whitman) having little commercial pear acreage further minimizes their importance. In the spring of 1945 the area known to be infested was extended slightly when several infestations, all on noncommercial properties, were found for the first time in Klickitat County, Wash.

The spray program in 1944 was less intensive than in earlier years, largely because of shortages in manpower and equipment. For the most part the dormant spray was omitted, but during the summer three cover sprays were applied against the nymphs, or immature psyllas, on a 15-day schedule. In addition to the spraying in the United States, much of which was done by cooperating growers, two nymphal sprays were applied to much of the infested area in British Columbia to protect the results of the program in the United States. A similar program is under way in 1945 in British Columbia. Pear growers in Canada are now actively cooperating in the application of the sprays.

OUTLOOK FAVORABLE FOR HALL SCALE ERADICATION

Intensive survey and inspection during 1944 and early in 1945 failed to reveal any important extension of the area infested by the Hall scale and, so far as known, the scale is still confined to the United States Plant Introduction Garden at Chico, Calif., and a small number of orchards within 5 or 6 miles of this garden. Two applications of oil spray were made in 1944 to all trees known to be infested and to trees in their general vicinity, and three applications were made to trees known to be heavily infested. As a result of these and previous applications, the scale population has declined and, apparently, there has been practically no spread. A fumigation program is now being started, and the prospect of ultimate eradication of this infestation appears favorable.

CONTROL OF MOLE CRICKETS IN FLORIDA

By burrowing in the soil mole crickets damage young plants, both in seedbeds and in fields. A considerable reduction in damage to

fall plantings of vegetable crops in 13 counties in Florida was made possible through a cooperative Federal-State program. The Bureau furnished and mixed 628 tons of bait (8 pounds of sodium fluosilicate to 100 pounds of wheat bran or steam-rolled wheat), which was distributed among 2,472 farmers and used on nearly 34,400 acres of crops. It was applied at the rate of 120 pounds per acre for seedbeds and 40 pounds per acre, in two applications, for field crops. The State of Florida, through its mole cricket control committees, arranged for transportation and distribution of the bait to the growers, the county governing boards accepting the full responsibility for any injury to livestock.

ARMY AIR FORCES BASES PROTECTED FROM DOG FLIES

For the fourth consecutive season the Army Air Forces allotted funds to the Bureau and the cooperating Public Health Service to conduct operations for the control of dog flies (stableflies) in the vicinity of Air Forces bases in northwestern Florida. These insects breed in great numbers in beach deposits of marine grasses during the summer and early fall and, if not suppressed, they seriously interfere with outdoor activities by their vicious biting.

By beginning control operations earlier in the breeding season, better results were obtained in 1944 than in previous years. Along 927 miles of shore line the deposits of marine grasses on a total of 566 miles were treated, dilute creosote being used on 383 miles and DDT on 41 miles. On 142 miles of shore line containing light deposits, the grass was scattered away from the water line to render it unsuitable for dog fly breeding. The DDT sprays, which were included primarily from an experimental standpoint, were found effective in controlling dog flies under the conditions prevailing in this area. Since DDT can be applied with small power sprayers mounted in light, shallow-draft boats, the cost of equipment and labor is much less than for applying creosote and faster and more flexible operations are possible. The swamp gliders are being employed during the current season. Adequate protection has been afforded to the Air Forces bases concerned, and incidentally to other military and naval installations and recreational areas nearby.

PHONY PEACH AND PEACH MOSAIC DISEASES LESS PREVALENT

Suppression and eradication of phony peach and peach mosaic diseases, as well as nursery protection and State quarantine enforcement, were continued in 1944 in cooperation with 16 Southern States extending from the Atlantic to the Pacific. Inspection covered 294 nurseries, growing more than 7,500,000 trees, and the 1-mile environs of these nurseries, as well as 54 budwood sources and their environs. Despite manpower shortages, orchard and nursery growers cooperated actively.

Only two nurseries in the southeastern phony peach area and one nursery and two dealers in the southwestern peach mosaic area were found ineligible for certification under the terms of the State quarantines. Illinois has been added to the list of 6 other States released from quarantine restricting the movement of nursery stock because of the phony peach disease. A number of counties in other States

infected with these diseases were released from quarantine regulation after 3 years of apparent freedom from infection.

More than 11 million orchard and home-yard peach trees in 16 States were inspected. Practically all the 72,053 diseased trees found were removed. A high percentage of the total mosaic-infected trees were found in commercial-producing areas in California and Colorado, where the infection is much less prevalent than formerly. The preponderance of phony peach infection continued to occur in the generally infected States of Alabama and Georgia, while in 7 contiguous States the incidence of this disease in known infected and adjacent properties continued to show a downward trend. No additional counties were found to be infected with either phony peach or peach mosaic disease during the 1944 season.

DUTCH ELM DISEASE CONTROL PROCEDURES MODIFIED

Operations during the year were modified to concentrate on determining where the Dutch elm disease occurs, on advising elm owners of the nature of the disease and recommending ways of combating it, and, finally, on testing methods of disease control in selected areas.

SCOUTING FOR INFECTED ELMs

Finding of the Dutch elm disease outside known limits of infection afforded a basis for establishing quarantine regulations to prevent movement of host material to uninfected areas. During the surveys scouts also made observations to determine the nature and extent of bark beetle infestations, and recorded the distribution and condition of elms in areas covered. Contacts were also made with local agencies and property owners to acquaint them with Federal and State control activities and to suggest local practices that would contribute to control of the disease.

Scouting efforts were concentrated on discovering infected elms in 20-mile zones outside of and surrounding the main disease region, comprising portions of Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, and Delaware, as well as around the isolated areas centering at Frederick and Cumberland, Md., Athens, Ohio, and Indianapolis, Ind. State officials were notified of all disease suspects and beetle-infested material discovered. Owing to the scarcity of qualified scouts, territory known to contain but few elms was not scouted.

Two partial surveys were made in the border zones, resulting in the addition of 297 minor civil divisions, comprising 8,339 square miles, to the known disease area in Connecticut, Delaware, Indiana, Maryland, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Virginia, and West Virginia. These additions more than double the 137 minor civil divisions, totaling 4,007 square miles, added the previous year.

More significant linear mile extensions were as follows: 22 miles northeast in Connecticut, 18 miles north in Massachusetts, 30 miles north in the Binghamton, N. Y., area, and 35 miles southwest in Pennsylvania. An infection was discovered 50 miles below Wilkes-Barre, Pa., along the Susquehanna River. Another 18-mile extension from Pennsylvania reached into the northern tip of Delaware. The disease center around Athens, Ohio, showed an eruptive type of spread,

with extensions of 20 to 25 miles in all directions except north, where spread was limited to 12 miles.

Surveys in the Frederick, Md., area, where infection had been discovered the preceding year, showed it to extend north into Pennsylvania and south into Virginia. No important extensions were found from the Indianapolis and Cumberland areas, nor were any new areas or recurrences of the disease in inactive areas discovered by the limited amount of exploratory work performed beyond the regular work areas. The presence of the disease in the Province of Quebec, Canada, was disclosed through culturing of specimens submitted to the Bureau by Canadian authorities. Later a Bureau inspector examined the infection center and informed Dominion officials of control practices in the United States. The disease has been reported in scattered areas adjacent to the junction of the Richelieu and St. Lawrence Rivers, about 60 miles north of the junction of New York, Vermont, and Quebec.

CULTURE OF ELM BARK AND WOOD IN THE LABORATORY

To supplement scouting for Dutch elm disease outside the quarantine-regulated areas, a pathological laboratory was operated for culturing elm material collected from trees suspected of harboring the causal organism. Continued progress was made in developing methods of culturing elm bark beetle galleries. This technique often discloses the presence of the fungus before symptomatic trees are observed. About 60 percent of all specimens sent to the laboratory were found to be infected. The plating of discolored-wood specimens on agar media was continued, as in former years. The use of low temperatures in incubation rooms was found to give improved results.

During the year 10,930 specimens of elm wood and bark collected by Bureau scouts were cultured, and 888 were found to be infected, as compared with 13,293 specimens cultured and 927 confirmations in 1943. In addition 728 specimens collected in experimental control plots or received from cooperators or private collectors were cultured, resulting in 478 confirmations. Similar culturing in 1943 involved 934 specimens and 809 confirmations.

COOPERATIVE FEDERAL-STATE CONTROL ACTIVITIES

All diseased trees and beetle-infested material found by Bureau scouts in Massachusetts, Delaware, Maryland, Virginia, and Indiana were removed and destroyed by State agents. In Connecticut all known diseased elms east of the Connecticut River were removed, except some worthless swamp elms in a section used for experimental spraying with DDT from a helicopter. New York State conducted a local control program in selected parts of the major disease area. New Jersey inspectors worked, in cooperation with local officials and property owners in the generally infected area, to locate and remove some of the more important diseased trees and associated bark beetle material. Pennsylvania, Ohio, and West Virginia took no effective steps to remove hazardous material found by Bureau scouts. The Gettysburg National Park removed a diseased tree and some beetle-infested material found on Park property. Ohio is considering a State quarantine for its known disease area. Rhode Island and Vermont have done some scouting.

EXPERIMENTAL CONTROL-PLOT STUDIES

Field work was performed in experimental plots to test various control methods that might be adopted by local agencies and property owners to save their valuable elms. The only diseased trees and beetle-infested material removed and destroyed at Federal expense were in these plots.

Plots were maintained at Morristown and Princeton, N. J., to test the effectiveness of thorough scouting and sanitation, as well as these operations supplemented by bark beetle trapping.

At Morristown, territory within a 2-mile radius of the center of the city was kept as free of disease and beetle-infested material as was possible by accepted scouting and removal practices. In a concentric outer zone 1 mile in depth observations were made on the location and amount of this material that might affect the central area.

Operations in the Princeton plot were similar, except that automatic traps that would attract and kill bark beetles were set up in the outer 1- to 2-mile zone as a substitute for the sanitation work. Princeton University removed confirmed trees found on University property.

A third experimental plot was established at Marietta, Ohio, to test the effectiveness of the prompt removal of symptomatic elms as a means of controlling phloem necrosis in the city and in a 1-mile surrounding zone. Bark beetle material found in the plot was destroyed. The city performed the removal work within its corporate limits, expending approximately \$3,000 for that purpose.

Thirty small centers around individual diseased trees were surveyed to study spread of the Dutch elm disease under uncontrolled conditions. Four of these centers showed no increase in disease, but 24 showed an average increase of 600 percent. In the course of the year 80 new cases developed on one plot and 130 on another.

In addition to the studies under uncontrolled conditions, 9 small experimental control plots were established around one or more valuable specimen elms, in sections having disease sources in the immediate neighborhood, to test the effectiveness of local control work. Significant results are not expected from these control plots until at least 3 years' data have been accumulated.

BARBERRY ERADICATION REDUCES LOSSES FROM STEM RUST

Destructive and widespread epidemics of stem rust, which occur periodically, and annual local losses have caused this disease to be recognized as a serious hazard to the profitable production of wheat, oats, barley, and rye. The economic importance of these crop losses stimulated vigorous prosecution of every recognized control measure. As a result losses from stem rust have been reduced from an average of 48 million bushels annually for the 14-year period 1915-28 to 24 million for the period 1929-42. This accomplishment has been largely brought about by the eradication of rust-susceptible barberries and the use of improved rust-resistant varieties of grain.

ACCOMPLISHMENTS IN 1944

During the war it has not been possible to make much progress toward completion of the remaining initial barberry-eradication work, and needed rework has fallen behind schedule in areas aggregating

33,365 square miles. With new barberry bushes appearing on large numbers of previously worked properties, and with many areas in danger of reinfestation, the rework program has been given first consideration. Initial work was confined largely to the State of Washington, which recently started barberry eradication, and a few restricted areas in Colorado, Virginia, and West Virginia. Accomplishments during the year included the destruction of 1,094,726 barberry bushes on 1,106 new and 1,804 reinfested properties. In addition 8,563 previously infested properties were reworked and found to be free of bushes. The eradication work involved complete coverage of 10,384 square miles.

A summary of the eradication work, by States, is shown in table 3.

TABLE 3.—Results of barberry eradication work, calendar year 1944

State	Area surveyed	Properties cleared		Bushes destroyed		
		New	Old	<i>Berberis vulgaris</i>	Native species ¹	Total
	<i>Square miles</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>	<i>Number</i>
Colorado-----	349	61	169	5, 676	390, 725	396, 401
Illinois-----	450	65	78	1, 496	-----	1, 496
Indiana-----	362	4	39	516	384	900
Iowa-----	549	38	128	1, 768	-----	1, 768
Michigan-----	816	250	326	7, 347	-----	7, 347
Minnesota-----	665	40	72	2, 776	-----	2, 776
Missouri-----	1, 146	32	17	176	-----	176
Montana-----	2, 088	0	0	0	-----	0
Nebraska-----	296	4	2	6	-----	6
North Dakota-----	1, 162	0	2	15	-----	15
Ohio-----	461	59	159	4, 049	-----	4, 049
Pennsylvania-----	20	5	93	24, 649	-----	24, 649
South Dakota-----	185	1	0	1	-----	1
Virginia-----	165	41	125	0	442, 951	442, 951
Washington-----	787	398	4	21, 404	-----	21, 404
West Virginia-----	48	0	149	202	184, 599	184, 801
Wisconsin-----	835	108	441	5, 986	-----	5, 986
Wyoming-----	0	0	0	0	-----	0
Total-----	10, 384	1, 106	1, 804	76, 067	1, 018, 659	1, 094, 726

¹ *B. fendleri* A. Gray and *B. canadensis* Mill.

More than 313,695,675 rust-susceptible barberry bushes have been destroyed to date on 129,177 properties within the control area, which embraces 1,078,201 square miles. As a result of the work that has been done, 738,213 square miles are now practically free of barberry bushes. The remaining territory consists of 129,059 square miles of initial work and 210,929 square miles that must be reworked one or more times in the future, to destroy any regrowth of barberries before seed is produced and reinfestation takes place. Periodic reworking of barberry sites at about 5-year intervals is necessary until there is no further recurrence of bushes.

The barberry survey and eradication work was aided by the use of informational material to keep the public conscious of the need for rework in areas that had been initially cleared of bushes, to encourage individuals to look for and report barberry bushes, and to obtain ac-

tive participation of property owners in the eradication work. The States of Michigan, Indiana, Ohio, Missouri, and South Dakota issued bulletins or circulars on barberry eradication, and 74 counties in Minnesota authorized or renewed authority for bounty payments on rust-susceptible barberries. During the year bushes were destroyed in 25 reported locations for which bounties were claimed. Informal talks, lantern slides, motion pictures, and news articles were used to inform farmers and others about barberry eradication and its relation to stem rust control.

DAMAGE DUE TO STEM RUST

No general epidemic of stem rust developed in 1944, although there were severe local epidemics in northern Kansas, northeastern Colorado, southeastern Wyoming, Nebraska, and South Dakota. East of the Mississippi River the aggregate amount of damage was negligible. Although barberry in Virginia, Washington, and certain other States began to rust heavily, seasonal drought almost completely checked rust development.

DISTRIBUTION OF PHYSIOLOGIC RACES OF STEM RUST

The most prevalent races of the wheat variety of stem rust identified during 1944 were race 56, constituting about 44 percent of all isolates, race 38 with 27 percent, race 17 with 21 percent, and race 19 with 7 percent. The following races were present in only small amounts: 14, 24, 36, 40, 49, 59, 139, and 142. The predominance of race 38 in the East and race 56 in the West was less pronounced in 1944 than in the previous 2 years. Races 2 and 5 of the oat variety of stem rust constituted 67 percent of the isolates, while races 8 and 10 made up 33 percent. This represents an increase in prevalence of races 8 and 10 of 13 percent over that of 1943, which may be significant, since these two varieties attack Boone, Tama, Vicland, and several other resistant varieties of oats, most of which were derived from Victoria \times Richland crosses.

From 84 aecial collections of stem rust on barberries, 16 races of the wheat variety of stem rust were obtained. Since there were 2 or more biotypes of several of the races, 21 distinct lines were identified from this relatively small number of collections. A study of the prevalence and distribution of races of stem rust in Mexico showed no important changes.

NURSERY INSPECTION

Applications to ship *Berberis* and *Mahonia* plants under the provisions of Federal Quarantine 38 were received from 35 growers during the calendar year. Permits were granted to 13 growers on the basis of 1944 inspection, and 22 were given permits without inspection, after a review of previous inspection records. Nineteen nurseries that had not requested permits were visited or contacted through correspondence and encouraged to remove their rust-susceptible barberry stock and to cooperate with the stem rust control program by propagating and offering for sale only immune or resistant varieties. These nurseries agreed to cooperate in this manner.

WHITE PINE BLISTER RUST CONTROL

The blister rust control program was conducted during 1944 on much the same basis as for the previous calendar year. Similar conditions, with reference to labor and equipment, stemming from the war effort and discussed in the last report, prevailed throughout the year.

APPLICATION OF CONTROL MEASURES

Ribes eradication was carried on in cooperation with Federal, State, and private agencies under the technical direction and leadership of the Bureau. The details of this work by regions are shown in table 4.

TABLE 4.—*Ribes* eradication work of all cooperating Federal, State, and private agencies for the calendar year 1944

Region	Initial eradication	Reeradication	Total	Effective labor	Ribes destroyed
	<i>Acres</i>	<i>Acres</i>	<i>Acres</i>	<i>Man-days</i>	<i>Number</i>
Northeastern.....	98, 659	315, 441	414, 100	29, 423	2, 491, 161
Southern Appalachian....	¹ 307, 928	34, 076	342, 004	² 14, 421	912, 662
North Central.....	49, 484	72, 530	122, 014	19, 441	2, 737, 714
Northwestern.....	10, 558	26, 908	37, 466	49, 525	2, 646, 894
Pacific coast.....	23, 385	30, 403	53, 788	53, 156	7, 397, 032
Total.....	490, 014	479, 358	969, 372	165, 966	16, 185, 463

¹ Includes 298,473 acres found free of *Ribes*

² Includes 2,826 man-days used in blocking out ribes-free acreage.

In general, the accomplishments of 1944 were about the same as for the previous calendar year, with continued emphasis on rework needed to maintain control of the disease on areas already initially protected. In remote forest areas 71 camps, employing about 4,500 persons at the peak of the season, were operated in connection with ribes eradication.

Other control work included the eradication of 3,714 bushes of cultivated black currants (*Ribes nigrum* L.) in the North Central States; the destruction of 1,540 ribes bushes from 9,089 acres in the environs of 19 nurseries to provide protection for over 62,000,000 young pines; and the removal of cankers from over 50,000 infected white pines to save them from being killed by blister rust.

SPREAD OF THE RUST

This disease has been reported from 28 States and is present in the principal white pine timber-producing areas in the eastern and western white pine regions and in the northern half of the sugar pine region. The chief points of interest in connection with the spread of the rust in 1944 were the finding of infected white pines in 5 new counties in northeastern Iowa, a 65-mile southward extension of the rust on ribes in California, the discovery of infection on ribes in Yellowstone National Park, and the finding of the disease on *Pinus flexilis* James within its natural range.

In California blister rust was found in Yuba County on sugar pines and ribes. The cankers on pines apparently originated in 1938. In addition diseased ribes plants were located for the first time in Placer, El Dorado, and Amador Counties. This extends the disease south-

ward to the center of the sugar pine belt, a distance of about 65 miles from the previously known limit of spread. In the sugar pine areas of southern Oregon and northern California more infected ribes and pines were observed than in any previous year, and *Ribes sanguineum* Pursh, in particular, was generally and heavily diseased. Many of the leaves were completely covered with telia. The leaves of *Ribes bracteosum* Dougl. also were heavily infected with rust. During the spring and early part of the summer the weather favored the infection of ribes, but it was not so favorable for the infection of pines during the latter part of the summer and early in the fall. The amount of pine infection that may result from the heavy ribes infection in 1944 will not be known until the rust has had a chance to become visible on the pines, 3 to 4 years hence.

In Montana blister rust on *Pinus flexilis* was found in the vicinity of Two Medicine Lake, Glacier National Park. This infection is the first reported finding of the disease on pine in the Western States, east of the Continental Divide, and the first on *P. flexilis* within its natural range. The cankers were probably of 1937 origin. The disease was also found in Wyoming for the first time, where it was located on *Ribes petiolare* Dougl. in the "Mammoth" area in the northwestern part of Yellowstone National Park.

The discovery of blister rust on native white pine in Allamakee, Delaware, Howard, Clayton, and Winneshiek Counties, Iowa, was of particular interest because much of the pine in that State grows in small, scattered shelter belts and planted stands. On ribes the disease was found for the first time in Cerro Gordo, Grundy, Hancock, Johnson, Jones, Kossuth, Muscatine, Scott and Webster Counties. These findings increase the number of counties in Iowa from which infected white pines and diseased ribes have been reported to 8 and 42, respectively. The rust was also located on white pines for the first time in Arenac and Gladwin Counties, Mich., Crawford and Greenlake Counties, Wis., and Stearns and Clearwater Counties, Minn. In Stearns County, Minn., the disease also was found on ribes for the first time.

The extension of the rust in the southern Appalachian States was limited to Patrick County, Va., where it was found for the first time on ribes.

In the Northeastern States blister rust is generally distributed on the white pines throughout their natural range. The amount of infection ranges from a small percentage of diseased trees in some stands to nearly 100 percent in others. Many stands of timber contain a large number of dead and dying white pines, as a result of infection that existed before the ribes was removed. The disease occurs every year on ribes during the spring, summer, and fall, with the infection ranging from light to heavy, depending upon the prevalence of weather favorable for its development. In the protected areas most of the smaller diseased trees have died and disappeared, and cankers resulting from recent infections are scarce. This is a complete reversal of the pine-infection status in these areas during the earlier years of the control program, when young cankers on white pines were more or less abundant in nearly every stand. The absence of such cankers in protected areas is very largely the result of perseverance in ribes eradication. It is also a good demonstration of the effectiveness of this work in establishing and maintaining control of the rust.

DEVELOPMENT AND IMPROVEMENT OF CONTROL METHODS

The completion of dosage tests with ammonium sulfamate on *Ribes lacustre* in the western white pine type shows that this chemical is more effective for the eradication of this species than any herbicides previously tested. Preliminary trials indicate that the sulfamate is also effective on *R. petiolare*. Further dosage tests of ammonium sulfamate sprays, with and without glycerol as a hygroscopic agent, were made on *R. bracteosum*, *R. inerme*, *R. roezli*, and *R. cereum*. Earlier data had shown ammonium sulfamate was most effective in moist cool soils and that early- or late-season treatments gave the best results.

Tests on greenhouse-grown *Ribes roezli* with 2,4-dichlorophenoxyacetic acid in a polyethylene glycol carrier showed that it was markedly toxic in concentrations as low as 0.08 percent.

A new sampling method, which facilitated recording of data on the status of blister rust infection in pine stands, was devised and used. This method adjusts the amount of check strip needed for a desired accuracy according to the pine stocking and the estimated amount of infection present.

Practical use was made of methods developed for evaluating ribes-regeneration factors in relation to approved practices for the management of western white pine. Studies were continued on the factors affecting moisture relations of ribes in pine-type soils, the germination and longevity of ribes and pine seeds, the development of new herbicides and new equipment for ribes eradication, and the effects of logging, burning, and grazing on ribes regeneration.

QUARANTINE AND REGULATORY ACTIVITIES

VARIOUS ACTIVITIES INVOLVED IN JAPANESE BEETLE QUARANTINE ENFORCEMENT

REVISION OF QUARANTINE REGULATIONS

Revised Japanese beetle quarantine regulations were issued, effective February 17, 1945. This revision brought within the regulated area two election districts in Allegany County and one election district in Charles County, Md., the city of Olean, Cattaraugus County, N. Y., the cities of Ashtabula, Conneaut, and Marietta, Ohio, and Washington Township, Lucas County, Ohio. The heavily infected area was extended to include additional townships in six Pennsylvania counties, all of Nassau County, N. Y., and the towns of Babylon and Huntington in Suffolk County, N. Y.

HIGHWAY INSPECTION SERVICE

Highway inspection stations were in operation on 7 highways in Virginia at the beginning of the year. At the peak of the season 23 inspectors were required to man the stations. Inspection was confined to examination of south-bound motortrucks. Five stations were operated 24 hours a day, and 2 for 16 hours a day. One station was closed on August 26, at the conclusion of the farm-products quarantine. The other 6 were discontinued the first week in September. A 1-man mobile patrol also operated on 2 Virginia highways.

Inspectors examined 78,472 trucks, 506 of which were found to be transporting uncertified produce. Of these lots 343 were certified at

inspection centers located near the highway stations. The inspectors also examined and certified 93 shipments and issued permits for movement of 51 truckloads to isolated regulated areas. Inspectors also examined empty south-bound trucks and took 904 live beetles from 298 of them. It was not necessary to prosecute a single violation during the season.

Through the Secretaries of War and Navy excellent cooperation was enlisted by military and naval forces in preventing spread of Japanese beetles by planes departing from airports in the heavily infested area. Inspectors also visited nonmilitary airports to inform commercial airlines of the dangers of such spread. Illustrated pamphlets were left for distribution to pilots, requesting their cooperation.

Experimental work to develop aerosols and sprays suitable for use in airplane interiors was in progress at the end of the year.

CERTIFICATION AND TREATMENT OF NURSERY STOCK

Many of the larger nursery establishments have abandoned lead arsenate in favor of ethylene dichloride dip for the treatment of nursery plots as a basis for certification. By the use of ethylene dichloride some growers have regained trade that they had been unable to supply under former treating procedures.

An improved mixture for use in ethylene dichloride treatment of nursery stock was authorized in September. Substitution of a surface-active agent for a fatty-acid soap produces a clear, emulsible mixture, which withstands low temperatures without separation and may be uniformly diluted with hard water. Promising results have been obtained in tests with a new insecticidal mixture of ethylene dichloride and ethylene dibromide.

Greater flexibility in the seasonal period during which ethylene dichloride might be used as a means of certification of plant materials was provided during the year. The earliest date for its use in the fall was advanced from October 1 to September 15 on the basis of diggings made to determine the larval stages present.

The use of tight railway refrigerator cars for the bulk fumigation of plant material with methyl bromide was authorized during the year.

A tentative pressure standard for gastightness of chambers used in the methyl bromide fumigation of plant material for compliance with certification requirements was established.

Tests were run to develop a suitable diluent and a more adaptable distributor for the application of powdered lead arsenate to nursery plots.

From 1 to 4 scoutings were made in 1,056 noninfested nursery and greenhouse units during the adult-beetle flight in the summer of 1944. Infestations were found on 71 of these units and in the vicinity of 25 others.

Approximately the same quantities of nursery and greenhouse stock moved under certification this year as in the previous period. Certifications from infested establishments included 26,787,769 plants and 75 tons of soil and manure. In addition 13,465,314 plants were shipped under certification from establishments determined as uninfested, and 23,695,047 plants and 1,205 tons of soil and manure were certified for movement between dealers within the regulated zone.

A total of 364,608 certificates of all types were issued to cover quarantined products moving to nonregulated territory, as compared with 199,053 certificates issued last year.

Investigations were made of 349 apparent violations of the quarantine regulations, most of them involving shipments of uncertified plants.

CERTIFICATION OF FRUITS, VEGETABLES, AND CUT FLOWERS

Imposition and termination of seasonal restrictions on farm products were operated this year on a fluctuating schedule based on emergence and disappearance of adult beetles. In the extreme southern sections of the heavily infested area the restrictions became effective on June 12 for the 1944 season and were lifted on August 25. For the remainder of the area it was in effect from June 26 to September 8. Certification requirements for cut flowers extended from the respective opening dates through September 30 in the entire area.

During the fiscal year 1,097,728 packages of fruits and vegetables were certified. A severe drought in the summer of 1944 caused a sizable reduction from the quantity certified in the last few seasons. Certifications involved the fumigation with methyl bromide of 3,857 refrigerator carloads and 115 truckloads of fruits and vegetables. Fumigation of refrigerator- and van-type trucks increased over the 1943 season, only 61 of these closed trucks having been fumigated the previous year. Many different kinds of farm products were fumigated, with no report of injury except to Williams Early Red apples. A total of 2,017 empty refrigerator cars and motor trucks were inspected or fumigated prior to loading with certified produce.

From farm products visually inspected, as contrasted with fruits and vegetables fumigated without determining their original condition of infestation, 1,432 living Japanese beetles were removed. From 16,697 packages of cut flowers inspected during the year 126 beetles were collected.

CERTIFICATION OF PRODUCTS UNDER THE GYPSY AND BROWN-TAIL MOTHS QUARANTINE

Paralleling activities of the last 2 years, this year's major work load evolved around the examination and certification of a multiplicity of forest products shipped to satisfy urgent demands for war material.

Increased intensity of infestation throughout much of the regulated area in New England was reflected in larger numbers of gypsy moths removed from inspected products. Interceptions totaled 1,414 egg clusters, 46 larvae, and 93 pupae of the gypsy moth, whereas the previous year's inspections netted only 349 egg clusters, 230 larvae, and 18 pupae.

The inspection load was increased considerably during the year. Shipments certified numbered 155,479, an increase of 65,000 over the previous period. The quantities of articles certified were somewhat under those of last season in a few categories, but the larger number of individual shipments certified increased demands on the inspection corps. Shipments of nursery stock and Christmas trees were slightly lower, while certification of pulpwood, involving a larger

amount of wood-lot scouting or piece-by-piece inspection, was considerably increased.

Products regarded as involving the greatest hazard of carrying infestations, that were certified for movement from the regulated area, consisted of the large quantities of rough lumber, such as unfinished boards and slab wood, used as crating, shoring, blocking, or lagging on equipment destined to all sections of the country for use in war industries or by the armed services. Through these inspection facilities the forest-products industry was assisted in the shipment, under certification, of 176,377,589 board feet of lumber and 102,664 cords of pulpwood.

An unusual instance of prevention of long-distance spread of the moth occurred in the heavily infested Cape Cod section of Massachusetts, where close inspection of 109 trailers, involved in a mass movement of housing facilities from Otis Field, Falmouth, to war-industry centers in Indiana resulted in the destruction of 309 gypsy moth egg clusters. Had unrestricted movement of this quantity of egg masses been allowed, the moths would in all probability have become established at those remote destinations.

A modification of the regulations effective August 26, 1944, authorized fumigation and certification of Christmas trees and evergreen boughs originating anywhere in the regulated area. Previously the movement of this material from the heavily infested area was prohibited.

Fifteen centrally located Christmas-tree-inspection centers were operated from mid-November to the latter part of December. Commercial shippers were required to bring their trees to one of these centers for visual inspection or chamber fumigation. This eliminated extensive travel that had been required of inspectors in former years when individual lots of trees were inspected at scattered points.

Because of the successful results of last year's carlot fumigation of evergreen products, commercial fumigation of Christmas trees and evergreen boughs at the expense of the shipper was inaugurated during the 1945 shipping season, and 105 carloads of trees and boughs were fumigated with methyl bromide. Inspectors for the States of Maine and Vermont performed the fumigations in these States, using mobile fumigation units loaned by the Federal Government and operated under the supervision of a Bureau inspector. Shippers furnished the fumigant and the States made a nominal charge for their inspectors' services. Some large shippers were able to procure their own equipment and perform the fumigations under the supervision of a Bureau inspector.

Vehicular inspection for the purpose of checking on the road movement of restricted articles was done at various periods during the year. Fifty-four truckloads of uncertified material were intercepted en route to noninfested territory. A few were inspected and certified by the intercepting inspector, but most of them were returned to the regulated zone for inspection.

Studies were made to establish definite temperature-dosage schedules for methyl bromide fumigation, using temperatures from 0° F. up.

Among the products shipped in large quantities that were inspected and certified during the year were the following:

Lumber-----	board feet--	190, 745, 680
Logs, piles, poles, ship knees, and ties-----	pieces--	1, 286, 380
Shavings-----	bales--	85, 112
Pulpwood-----	cords--	102, 664
Cable reels-----	number--	55, 060
Miscellaneous forest products-----	pieces--	130, 745
Shrubs-----	number--	2, 979, 169
Deciduous trees-----	number--	289, 189
Evergreen trees-----	number--	2, 089, 068
Seedlings and small plants-----	number--	668, 835
Boughs, balsam twigs, and mixed greens-----	boxes or bales--	31, 980
Christmas trees-----	number--	297, 838
Granite-----	pieces--	10, 120
Paving blocks-----	number--	54,000

EFFORTS MADE TO INCREASE EFFECTIVENESS OF DUTCH ELM DISEASE QUARANTINE

Almost complete stoppage of Dutch elm disease control work in some States, following abandonment of the practice of removing and destroying infected elms at Federal expense, increased the importance of quarantine measures to prevent the movement of hazardous elm material from neglected disease areas to noninfected territory.

A survey was made of the movement of elm and of its uses in the regulated areas and in adjacent sections. Steps were also taken to increase the effectiveness of quarantine enforcement by preventing the outward movement of hazardous material. Visits were made to elm cutters and shippers in disease areas, and measures were suggested to reduce the hazard of their operations with respect to disease spread. Inspections were made of environs of selected nurseries having elm plantings to determine the feasibility of certifying elms under a permissive rather than the present embargo type of quarantine.

CERTIFICATION OF CITRUS FRUITS UNDER THE MEXICAN FRUITFLY QUARANTINE.

The citrus-producing area in Texas regulated under Quarantine No. 64 on account of the Mexican fruitfly produced, during the past season, the largest crop of citrus fruit on record. This production amounted to 26,454,600 80-pound packed boxes. No new infestations were found outside the present regulated area. In the lower Rio Grande Valley, which is the most heavily infested part of the regulated area, traps revealed that the fruitfly population was extremely low. Field inspections resulted in the finding of only 255 infested properties. Although fewer infestations were found this year than during the preceding season, the amount of fruit sterilized increased slightly. A total of 67,941 tons of grapefruit were sterilized by the high-temperature method. No oranges were sterilized.

Tables 5 and 6 give data on the amount of fruit production, the number of flies trapped and infestations found, and the amount of citrus fruit sterilized in Texas since control of this insect was undertaken.

TABLE 5.—*Infestations of Mexican fruitfly in Texas, fiscal years 1935-45*

Fiscal year	Boxes of fruit produced	Flies trapped	Larval infestations	Date harvesting season closed ¹
	<i>Number</i>	<i>Number</i>	<i>Number</i>	
1935-----	3, 253, 680	371	30	Apr. 2.
1936-----	3, 400, 920	256	5	Mar. 31.
1937-----	11, 052, 360	4, 714	1, 062	Do.
1938-----	12, 573, 720	712	218	Apr. 30.
1939-----	17, 117, 280	13, 687	2, 141	{ May 15 (G). June 15 (O).
1940-----	16, 723, 800	6, 157	² 582	Apr. 30.
1941-----	15, 911, 280	979	552	May 31.
1942-----	16, 447, 320	244	259	Do.
1943-----	19, 571, 400	224	291	Do.
1944-----	21, 299, 760	1, 796	576	{ June 15 (G). No closing (O).
1945-----	26, 454, 600	43	255	{ June 15 (G). No closing (O).

¹ (G) grapefruit, (O) oranges.
² Includes 4 infestations in 1939.

TABLE 6.—*Citrus fruit sterilized in Texas, fiscal years 1939-45*

Fiscal year	High-temperature method		Low-temperature method	
	Grapefruit	Oranges	Grapefruit	Oranges
	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>
1939-----	44, 150	2. 25	0	2. 1
1940-----	8, 927	. 75	298. 6	168. 8
1941-----	9, 937	0	53. 6	0
1942-----	3, 619	0	0	0
1943-----	23, 394	0	0	0
1944-----	62, 372	26	0	0
1945-----	67, 941	0	0	0

PROGRAMS IN CONNECTION WITH PINK BOLLWORM QUARANTINE

CHANGES IN REGULATIONS

A revision of the pink bollworm quarantine (foreign) and regulations provided for the entry of cottonseed and cottonseed hulls from sterilized seed produced in portions of the State of Tamaulipas, Mexico, effective November 11, 1944. Comparable infestations of the pink bollworm existed in parts of the lower Rio Grande Valley of Texas and a contiguous area of Mexico, and since the Departments of Agriculture of Mexico and of the United States are jointly working to control the insect in these border areas, it appeared that entry of sterilized cottonseed produced in portions of Tamaulipas for milling and handling under the same precautions as apply to seed produced in the contiguous area of Texas would not involve additional risks.

At the same time the excepted locality of the Imperial Valley was extended to include a small portion of the Valley that extends into northwestern Sonora.

Effective November 9, 1944, the pink bollworm quarantine (domestic) and regulations were revised to include recently found infestations of the pink bollworm in southern Texas, to classify as heavily

infested the counties of Cameron, Hidalgo, Starr, and Willacy, hitherto considered as lightly infested, and to place additional restrictions at point of origin or destination on the movement of cottonseed produced in heavily infested areas to designated oil mills located within contiguous lightly infested areas. The infestations causing the additions to the area under regulation were found in the Texas counties of Aransas, Atascosa, Bee, Caldwell, Gonzales, Guadalupe, Hays, Karnes, Refugio, San Patricio, Wilson, and those parts of McMullen and Live Oak Counties not heretofore under regulation.

COOPERATIVE WORK WITH MEXICO

It was possible for supervisory leaders and their staffs to aid the Mexican officials in the various areas in their enforcement of pink bollworm regulations. This assistance included visits to many farms, processing plants, warehouses, and transportation facilities, as well as conferences with the official and private cooperating agencies. The basic understanding of the over-all situation gained during the last year is leading to improvement in procedures and methods. Definite progress appears to have been made toward unification of the pink bollworm control operations in the two countries.

PROGRAMS IN THE VARIOUS REGULATED AREAS

In order to decrease the number of overwintering larvae in the 1944 cotton crop in the lower Rio Grande Valley of Texas, the State deadline for stalk destruction in the counties in that area was set as September 15, which is 15 days earlier than in previous years. However, for the third consecutive season heavy rains occurred during the period of field clean-up, preventing completion of stalk destruction by the designated deadline, which was postponed to September 30 and subsequently to October 15. The host-free period in the Valley, although not established so early as was desired, was maintained more effectively this year than ever before with a minimum of grubbing financed with public funds. The program for the 1945 crop includes a cotton-growing period 65 days shorter than the previous one and a stalk-destruction deadline date of August 31. Texas regulations required destruction of cotton plants in all other infested counties in southern Texas, and a fairly effective host-free period was maintained during the winter months. Unless such a program is maintained in that area, cotton will continue to grow and produce food for the pink bollworm to breed in.

The noncotton zone in southwestern Louisiana has been lifted and a 1945 crop planted in that area. No infestation was found in the 1944 crop in the regulated area established adjacent to the noncotton zone. A total of 1,043,909 bales of cotton were ginned at 694 gins in the regulated areas of Texas, New Mexico, Arizona, and Louisiana; 398,865 tons of seed were sterilized; 357,327 tons of seed were processed at the 51 designated oil mills; and 12 compression plants compressed 488,836 bales of lint and 5,670 bales of linters. A total of 8,823 bales of Mexican linters were fumigated. At the two road stations maintained to inspect highway traffic from the quarantined area in the lower Rio Grande Valley, 24,682 cars and trucks were inspected, and 9,015 were found to be carrying contraband material, which was inter-

cepted. Extensive contacts were made with ginner in the newly quarantined areas to determine the progress made and to aid in obtaining and installing units to heat cottonseed. Since the units to be installed at the gins would not be ready for operation in time to sterilize seed from the 1944 cotton crop, the Bureau sponsored a cottonseed-heating program whereby all seed on hand was heated to the required temperature.

INSPECTION CONTINUED AT TRANSFER POINTS

Transit inspectors located at 20 strategic transfer points examined during the fiscal year more than 1,320,000 mail, express, and freight shipments, moving via common carrier, to determine compliance with Federal domestic plant quarantines; of these shipments 1,848 were found to be moving in violation of the regulations. Twenty-four shipments were reported as violations of the regulations governing the movement of plants into the District of Columbia, and 654 were reported to State officials as apparent violations of State nursery-inspection regulations and quarantines, including those on account of the phony peach disease and the sweetpotato weevil.

During the period of heavy flight of the Japanese beetle, transit inspectors were assigned to strategically located carload-interchange yards at Crestline and Columbus, Ohio, where 3,435 carloads of produce and nearly 200,000 waybills covering carloads of produce, moved from the heavily infested Japanese beetle area to points outside the regulated area, were examined. Interceptions were made of 46 carloads of produce moving in violation of the Japanese beetle quarantine regulations. Most of these were diversions to nonregulated points without fumigation, after original consignment to points within the regulated area.

TERMINAL INSPECTION OF MAIL SHIPMENTS

The States maintaining terminal inspection, authorized by the act of 1915, of mail shipments of plants and plant products under the procedure carried out in cooperation with the United States Post Office Department, which provides for turning back or disinfecting shipments found infected, are Arizona, Arkansas, California, Florida, Idaho, Minnesota, Mississippi, Montana, Oregon, Utah, and Washington. The District of Columbia, Hawaii, and Puerto Rico also maintain this procedure. Terminal inspection formerly carried on at New Orleans, La., and in Oklahoma has been discontinued.

The States that have availed themselves of the provisions of the 1936 amendment to the terminal-inspection act for the enforcement of State plant quarantines are Arizona, Arkansas, California, Florida, Minnesota, Mississippi, Montana, Oregon, and Washington.

FOREIGN PLANT QUARANTINE ACTIVITIES GREATLY CHANGED BY WAR CONDITIONS

MARITIME PORT INSPECTION

Developments in the war situation strongly affected plant-quarantine enforcement at maritime ports. Ship arrivals increased 30 percent over those of 1944 to a total of 35,555, which is 16 percent greater than the average of the 10 preceding prewar years. The abolition of the convoy system in the Atlantic toward the close of the year and the

availability of some advance information as to expected arrivals made it possible to utilize personnel more effectively because of a more even flow of work. The increase in shipping was accompanied by an increase in the demand for plant-quarantine protection over preceding war years, both as to cargoes and passenger lists. In the latter part of the year troop transports and commercial vessels carrying some passengers placed an added load on port staffs, temporarily reduced by the assignment of inspectors to meet the heavily increased volume of air traffic.

The record of ship inspections appears in table 7. The data given in this table do not include those for ships engaged only in Great Lakes trade.

TABLE 7.—*Number of ships arriving, inspected, and bearing prohibited plant material fiscal year 1945*

Origin	Arriving	Inspected	Bearing prohibited material
Foreign ports, direct-----	28, 209	28, 099	5, 368
Foreign ports, via United States ports-----	4, 208	3, 959	260
Foreign ports, via Hawaii-----	459	459	65
Foreign ports, via Puerto Rico-----	26	26	13
Hawaii, direct-----	1, 851	1, 851	256
Hawaii, via United States continental ports-----	98	98	-----
Puerto Rico, direct-----	272	272	42
Puerto Rico, via United States continental ports---	30	30	-----
United States ports, via Panama Canal-----	402	400	53
Total-----	35, 555	35, 194	6, 057

CARGO INSPECTION

Importations of plants and plant products increased during the year. The totals were as follows: Fruits and vegetables, 11,010,296 containers, 57,517,212 bunches of bananas, 5,597,635 pounds, and 25,895 units; nursery stock and seeds, 61,572 containers, 118,233 pounds, and 1,898,898 units; cotton lint, bagging, and cotton products, 426,061 bales, 1,069,209 containers, and 53,706,328 pounds; fibers and cereals, 10,680,576 bushels, 634,644 containers, 446,120 pounds, and 158,512 dozen.

The foregoing totals do not include several thousand importations of fruits and vegetables over the Mexican border in such small quantities that no entries are required by customs and no plant-quarantine record is made of them. Each of these small lots was inspected before release, and a large outlay of inspector-hours was required to examine them all, particularly at the larger ports.

Through the cooperation of the customs officers and the Canadian Department of Agriculture, a number of lots of restricted plant material were admitted in accordance with regulations at Canadian border ports where no plant-quarantine inspectors are stationed.

DISINFECTION

The wartime character of commerce in restricted plants and plant products is reflected in the amount and type of plant material treated

under supervision of inspectors and collaborators of this Bureau. The number of bales of cotton, linters, and bagging treated was 196,901, approximately the same as in 1944. The 931,570 pounds of cottonseed cake and meal treated represent only about 3.5 percent of the 1944 volume. Only 41,094 cases of liquor with weevil-infested vetch contaminating the straw jackets around the bottles required fumigation, in view of the steps previously taken to encourage the use of suitable packing materials. The 1,881,692 units and 5,667 containers of plants, cuttings, bulbs, roots, and other plant-propagating material treated amounted to about 50 times the volume of this class of material treated in 1944; in addition, 93,172 pounds of seeds were safeguarded by treatment. A total of 7,106 samples of cotton lint and linters, 18,686 containers of broomcorn, 179 containers of other miscellaneous restricted plant products, and 789 lots of returned Army and Navy materials were fumigated or otherwise treated.

AIRPLANE INSPECTION

The Army program for returning troops from Europe by airplane accelerated the rapid growth of air-borne commerce in 1945. During the year 45,728 airplanes were inspected at 42 ports of entry. This represents an increase of 112 percent over 1944. It was necessary to provide plant-quarantine protection at 5 ports previously without this service, to meet the demands at other ports normally handling surface traffic, and to increase the staff assigned to airplane inspection at still other ports. The finding of prohibited plant material in 7,299 of the airplanes inspected, much of which was fruit of tropical and subtropical origin, emphasizes the importance of plant-quarantine clearance of aircraft from abroad, particularly so since two-thirds of the arrivals in 1945 landed on airports in the southern part of the United States. The speed with which a plant pest can be transported to a new environment by air further emphasizes the gravity of the pest risk associated with air commerce. The year marked the inauguration of plant-quarantine inspection in Alaska, a step necessitated by air traffic into the Territory.

In connection with airplane inspection 2,442 interceptions of insects and plant diseases were made. While many of these pests, including mosquitoes, were stowaways that might menace public health, plant pests of economic importance were found in plant material carried in baggage, cargo, mail, and stores. Among the insects found were the pink bollworm, the melon fly, the Mexican fruitfly, the West Indian fruitfly, and four other species of *Anastrepha*—*A. serpentina* Wied., *A. suspensa* (Loew), probably *A. fraterculus* (Wied.), and an undetermined species. Of the 83 interceptions of plant diseases, 15 were of 11 different organisms on orchids, 21 were of 11 different organisms on miscellaneous flowers and other ornamentals, 22 were of 9 different organisms on rice, 7 were of organisms on citrus fruits, and 18 were of 14 organisms on miscellaneous food plants.

FOREIGN PARCEL-POST INSPECTION

Parcel post from members of the armed forces abroad presented in 1945 an even greater problem in providing plant-quarantine protec-

tion than that discussed in last year's report. During most of the year inspection was provided at all the principal points where such mail is handled by the customs. The records obtained by inspection of a part of the huge volume of parcel post, on inadvertent noncompliance by military and naval personnel with the directives of their respective services on the subject, are utilized in bringing about a more effective observance of plant quarantine at the point of mailing. A total of 3,045,324 packages were examined, an increase of approximately 2,000 percent over 1944. Of these 1,623 were refused entry, in whole or in part, because they contained prohibited plant material, 2,217 were diverted to another port for disposition, and 2,440 were released under permit.

MEXICAN BORDER SERVICE

The number of inspections of freight cars from Mexico was decreased in 1945 to 64,995 from the total of 67,755 for 1944, a decrease of 4 percent. It was necessary to fumigate 9,251 of these, a decrease of 29 percent over 1944. The sales, at \$4 each, of coupons valid for the fumigation of a freight car, amounted to \$36,708. The decrease in this activity is due in part to a reduction in traffic and in part to the employment of procedures for waiving fumigation when it can be done without risk of pest entry.

In addition 5,390 pullman and passenger coaches were inspected upon entry into this country, a substantial increase of 17 percent over 1944. A total of 4,749,491 other vehicles and 930,545 pieces of baggage were examined in cooperation with customs officials, representing increases of 4 and 15 percent, respectively.

INSPECTION IN HAWAII AND PUERTO RICO

As in 1944, the predominant emphasis in 1945 in the enforcement of quarantines governing the movement of plants and plant products from Hawaii to the mainland is on the preflight inspection of airplanes and the examination of mail, baggage, and express. There is at this time very little commercial movement of fruits and vegetables to the continent, with correspondingly little call for inspection and certification. On the other hand, preflight inspections of aircraft are over 45 times as numerous as in 1942, and the total number of pieces of airplane passengers' baggage inspected is also greatly increased. The inspection of mail and express packages and the baggage of passengers on surface vessels continue at approximately the 1944 levels. Since not all the mail of the armed forces can be made available in Hawaii for plant-quarantine clearance, approximately 22,000 parcel-post packages are inspected monthly at mainland ports.

In Puerto Rico emphasis continues to be on the inspection of surface vessels and aircraft to prevent both the introduction of foreign plant pests and the spread of injurious pests of Puerto Rico to the mainland. Insular inspectors, acting as collaborators, assist in this work. As in Hawaii, local needs for fresh fruits and vegetables leave few of those products for shipping to the mainland, and there is at present almost no demand for inspection and certification for movement under Quarantine No. 58.

DEPARTMENTAL PLANT MATERIAL AND DISTRICT OF COLUMBIA INSPECTION

A total of 324 shipments of incoming domestic material (40,218 plants, cuttings, bulbs, etc., and 2,749 lots of seeds) and 2,011 shipments of outgoing domestic material (101,036 plants, cuttings, bulbs, etc., and 10,938 lots of seeds), including material shipped by the United States Department of Agriculture, were inspected in the enforcement of the regulations governing the movement of plant material into and out of the District of Columbia. Some form of treatment for the elimination of pests in these shipments was given to 63,086 plants, 3,367 lots of seeds, and 501 parcels containing plant material not for propagation. In addition 19,383 containers were examined at the post offices, express offices, and freight stations, and 12 truckloads containing 84,570 plants consigned to retail merchants in the District of Columbia were checked on arrival for proper certification.

INSPECTION OF PLANT-INTRODUCTION AND PROPAGATING GARDENS

Plant material that is being propagated at plant-introduction and propagating gardens maintained by the Bureau of Plant Industry, Soils, and Agricultural Engineering is inspected regularly for the presence of plant pests. Such material distributed from the gardens at Coconut Grove, Fla., and Mandan, N. Dak., was inspected by State officials cooperating with this Bureau. The inspections at Chico, Calif., were handled jointly by an inspector from this Bureau and an entomologist from the California Department of Agriculture. Material distributed from the District of Columbia, Maryland, and Savannah, Ga., stations was examined by Bureau inspectors. The following were examined prior to distribution from these stations during 1945: 179,182 plants, 2,443 bud sticks and cuttings, 6,375 roots and tubers, and 685 shipments of seeds.

INTERCEPTIONS OF PROHIBITED AND RESTRICTED PLANTS AND PLANT PRODUCTS

The interceptions of prohibited and restricted plants and plant products in 1945 were as follows: In baggage, 51,628; in cargo, 315; in mail, 2,513; in quarters, 6,498; in stores, 7,270; total, 68,224, an increase of 18 percent over 1944. Customs officers at Canadian and Mexican border ports where no plant-quarantine inspectors are stationed made additional interceptions of plants and plant products.

The Bureau continues to enjoy the full cooperation of customs personnel in the enforcement of foreign plant quarantines at ports where traffic conditions do not now warrant the services of an inspector. The appropriate agencies of the Army and Navy are also working to make plant quarantines effective with respect to traffic of the armed forces. The activities of these agencies are helpful in maintaining the safeguards against pest entry.

PESTS INTERCEPTED

During the inspection of foreign plants and plant products, and of such products received on the mainland from Hawaii and Puerto Rico, inspectors and collaborators of the Bureau collected insects be-

longing to 1,060 recognized species and others distributed among 731 genera and families, as well as fungi, bacteria, nematodes, viruses, and algae belonging to 282 recognized species, and large numbers of other pathogens that could be referred to genus, family, or general group only. Some of these intercepted pests were undescribed species and of unknown importance, others were of species not heretofore represented in the Department's collections, and many were of plant pests known to be important.

The combined total of 51,816 interceptions of insects and diseases were taken as follows (figures refer to number of interceptions): In material offered for entry for consumption 26,732 insects, 13,514 diseases; in material offered for entry for propagation 3,813 insects, 924 diseases; in material not offered for entry, such as in-transit shipments and materials in ships' stores, quarters, etc., 5,237 insects, 1,596 diseases; total, 35,782 insects and 16,034 diseases.

CERTIFICATION FOR EXPORT

A total of 2,198 export certificates covering 860,696 containers, including 76 carloads of bulk materials, were issued to meet the sanitary requirements of foreign countries. Certificates were issued at 26 ports covering 37 commodities which were exported to 61 foreign countries.

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Agricultural Research Administration

